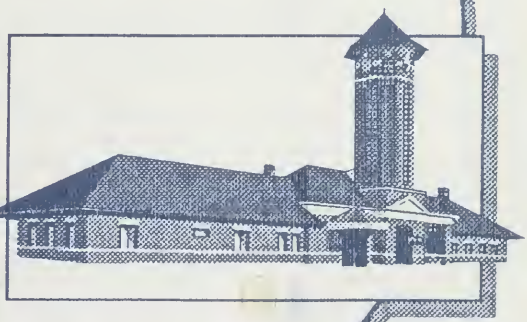
PROCEEDINGS

OF THE

101st ANNUAL CONFERENCE

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION



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Proceedings of the
101st Annual Conference
of the

American Railway Bridge and Building Association

Held at the

Westin Hotel
Chicago, Illinois

September 22-25, 1996

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18154 Harwood Avenue, Homewood IL 60430
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In Memoriam

Joseph W. Chambers

President 1980 – 1981
Vice President 1977 – 1980
Director 1969 – 1972, 1976 – 1977
Deceased December 18, 1996

William H. Nelson

Seminar Coordinator 1994 – 1996
Vice President 1990 – 1991
Director 1986 – 1990
Deceased November 3, 1996

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JOINT SESSION

Monday, September 23, 1996

Opening Remarks

President Bradley: Good Morning. As president of the American Railway Bridge and Building Association and on behalf of the Roadmasters and Maintenance of Way Association of America, I declare the 101st annual conference of the American Railway Bridge and Building Association and the 108th annual conference of the Roadmasters and Maintenance of Way Association to be open and in joint session.

Before we begin, let's do a little housekeeping – please note there are exit signs above each door. We are on the second floor and there are stairways right outside the door and at the other end of the hallway near the Cotillion Room where the REMSA coffee bar was located. The security staff here is trained in administering CPR and, we are in Chicago, so by just dialing 911 you will reach emergency services.

I welcome each of you here today and I would like to thank you for your participation and support in both of these fine organizations. The program promises to be both interesting and problem solving and should be of interest to all so we don't want to waste any time here today.

We, once again, have survey forms! As you all know, survey forms have become a part of our lives. Completing these won't take much of your time, but please make an effort to complete them and turn them in to the registration desk or any of the directors you may see. We do read them and try to act upon your suggestions.

It is proper at this time that we pause to ask for divine guidance and inspiration prior to beginning this conference. At this time I would like to call on someone who is very instrumental in getting me involved and who is also one of B&B's past presidents, John Kapp, to give the invocation. John.

INVOCATION

John Kapp

B&B Past President
Assistant Chief Engineer – Construction Eastern Lines
Conrail

Let us pray. Kind heavenly Father, we thank You for all the blessings that You have bestowed upon us and our families during the past year. We ask for Your continued support of the leaders and speakers at this year's conference as they share their knowledge and wisdom with all of us so that we may use what we learn to develop new ideas that will better serve all mankind. Help us to enjoy the fellowship of our gatherings, and to develop new friendships that will grow throughout our lives.

Be with us throughout the upcoming year to grant us the peace and relaxation that only comes through our faith and belief in You, Amen.

President Bradley: Thank you, John. At this time I would like to introduce the B&B Board of Directors. As I call their names, I ask they stand and be recognized. I also ask the audience to hold your applause until all have been introduced.

Senior vice president, Joe Lileikis, senior engineer structures, Amtrak; junior vice presidents, Bob Carter, manager public programs, BNSF; David Franz, bridge engineer, Kansas City Southern; treasurer, Donald Lewis, assistant engineer structures, Illinois Central.

Directors, Mark Johnson, manager of structures, BNSF; Dale Bartholomew, senior project manager railroad facilities, Sverdrup Corporation, Pat Barrett, engineer construction and maintenance, BNSF; Dave Cook, superintendent B&B, Montana Rail Link; Dick Dummar, Manager architectural design, Union Pacific; Richard Calhoun, associate, CTE; Willie Benton, engineer structures, Norfolk Southern, and Bill GeMeiner, manager methods and research, Union Pacific.

You may now applaud.

At this time, I'll turn the podium over to Kendall Koff, president of Roadmasters and Maintenance of Way Association.

WELCOME BY PRESIDENTS

President Koff: Thank you. As president of the Roadmasters Association, I would like to add my welcome to all attendees of this conference.

At this time, I would like to introduce Roadmasters Board of Directors and ask all of them to stand. Please hold your applause until all have been introduced.

First vice president, Wayne Russell, maintenance engineer, BNSF; second vice president, Ronald Poulsen, senior project manager, HDR Engineering; treasurer, Darrell Cantrell, engineer of track, BNSF.

Directors, Al Cloutier, division engineer, Amtrak; Reuven Shiloh, assistant chief engineer planning and support, Conrail; Peter Murgas, manager re-engineering, Norfolk Southern; Bob Davis, production manager ties, Southern Pacific; Dwight Clark, director quality management - engineering, Union Pacific; Bob King, supervisor engineering maintenance, CP Rail; Tom Long, manager engineering services, Indiana Harbor Belt; Joe Riley, engineer standards,

Metra; Dave Griffith, assistant division engineer, Norfolk Southern; Chris Dodge, chief engineer, RailTex; Andy Sensing, engineering superintendent, Illinois Central.

You may now applaud.

President Bradley: At this time, I would like to introduce Jim Beran, president of the American Railway Engineering Association, and chief engineer for Union Pacific, for a few remarks this morning.

Mr. Beran: Thank you, Ken Koff and Mike Bradley, for this opportunity to say a few words to the Roadmasters and B&B Associations.

There are two primary reasons for being up here...and they are very traditional. First, I want to tell you a little bit about what is going on at AREA and, second, I want to reinforce the cooperation and brotherhood that exists between our organizations.

What's going on at AREA? On Wednesday, October 2, we will begin our annual committee chairman's meeting and regional conference in Mexico City. The conference will conclude on Friday, October 4, with a train trip to Vera Cruz.

Committee work which results in the AREA Manual of Standard Practice is the primary product that we have to offer to the industry and it is vitally important. This annual meeting is the one time dedicated each year for the chairmen and board members to sit down together and work on all of the latest issues.

In recent years we have been spending a lot of time on revamping processes to make it easier and quicker for the work of the committees to get published. We have been trying to break apart the traditional processes and become more customer responsive. Our customers are primarily transportation and they tell us that they need better response time, among other things, and we are working on it.

Because we are an association of North America, with many members from Canada and Mexico we do rotate the fall conference to those two countries. Every time we do it has been a very fulfilling experience. Our partners to the north and south are always very gracious hosts.

Other news from AREA — well, it's the same as yours. There is some cooperative work being done on a potential merger between our associations.

In AREA we fully recognize the value added to the industry that the Roadmasters and B&B Associations have to offer. We are all three very good associations with many good people, all working in the same industry for the same customers with the same purpose — to assure that the infrastructure of our railroads are reliable and safe.

How we do that is through developing useful modern tools and disseminating those tools to the industry. The tools can be maintenance practices, recommended design practices, educational symposiums, special reports. In other words, these tools are highly varied and should be of any means we can dream up to educate and inform the employees of the railroads, suppliers, consultants, and other associates of the industry. With the advent of larger mergers of railroads this is even more important.

At the UP for example, I started to work in 1970 and since 1983 we were known as the UP, WP, MP, Katy, CNW and SP. With each of these mergers we have lost people and experience and know-how that is very difficult to replace.

The three associations, Roadmasters, B&B, AREA collectively provide just about the only viable means of starting to replace what the industry has lost. I believe that we can do this even better if we are together as one and I sincerely hope this is possible.

Mergers are tough. Our efforts to try and create a leaner, more focused, a more industry-responsive association will not happen unless the membership of all three associations approve it by a vote of their full membership so our plans have to be good and fair and the best for the industry or it just will not be approved. It has to provide a means for every individual to add value and be a part of the team.

Anyway, that's what is going on at AREA and that also summarizes how I feel about the brotherhood of our associations. Good luck to everyone in the future and thank you all.

President Bradley: It is my pleasure to now introduce Bob Kramer from REMSA. This year REMSA again extends their hospitality to us throughout this conference by supporting the continental breakfast that we enjoy each day, in addition to opening their doors to us each evening. REMSA members are also involved in research and development of new equipment and easier ways for us to perform our work. We welcome their participation on our program and in developing the subject presentations given each year. Bob.

Mr. Kramer: Members of the American Railway Bridge and Building, Roadmasters and the Maintenance of Way Associations, and guests, it is my pleasure to be here representing 202 REMSA members. We welcome you back to Chicago and want to convey our best wishes for a successful technical conference.

A great deal has changed since we met last year in Minneapolis. It is an exciting time and also a bit nerve wracking in that there's a change in store for all of us. And, of course, change forces us to do something, usually something we hadn't planned to do or change.

I am referring, of course, to the impending consolidation of the B&B, Roadmasters, and the AREA.

The group that is overseeing this change has a daunting task before them, and they are going to great lengths to do it right. They recognize and want to preserve each discipline currently represented individually. They respect and want to reflect each association's proud history in some way. They have adopted a policy of inclusiveness. And REMSA is sure that the end result will be the very best from each of your groups. We expect a great deal and have faith in you and your efforts.

To satisfy your thirst and fill you with food, REMSA will again sponsor breakfast bars. One was held this morning, and one will be held beginning at 7:00 a.m. tomorrow morning and Wednesday morning in the Cotillion Ballroom. Then there is also the Tuesday night reception in this room starting at 6:00 p.m. All registered railroaders and their spouses are guests of REMSA. Please pick up your invitation at the REMSA table and join the fun.

In the evening, 22 hospitality suites will be open – all sponsored by individual REMSA members. I encourage you to drop by. There's usually a lot to eat in these places! To help you find these hospitality suites, a list of these suites is on the big board outside this room. Take a look.

We want to remind you that REMSA's next big show is September 1997 in Kansas City, Missouri. The Norfolk Southern is giving REMSA space in their North Kansas City Yard for outdoor exhibits and we appreciate their cooperative spirit. It has been a pleasure to work with them. We are looking forward to a good crowd for the exhibition and your conferences and are working to make that happen.

To Presidents Mike Bradley and Ken Koff, our congratulations on jobs well done and successes enjoyed. Both of you have had to take on extra responsibilities this year because of the impending association consolidation, but both of you are up to the task; and, we believe, success is in sight. REMSA help and assistance is, of course, never far away; and we are ready to aid you at any time.

Thank you.

President Bradley: Thank you, Bob. At this time it is my pleasure to introduce Timothy Dwyer, senior vice president unit train operation for Conrail. Mr. Dwyer began his railroad career with the former New York Central System, a predecessor of Conrail, in 1967 as an engine service trainee in his hometown of Rochester, New York. In 1972, following two years of military service in the U.S. Army, he entered the sales department of the railroad and held various sales management positions over the next 12 years from West Virginia to California. In 1984 he was appointed assistant vice president sales for Conrail and in 1988 assumed responsibility for Conrail's Metals Business Group. In 1992 Mr. Dwyer returned to the operating department as general manager of Conrail's Philadelphia-based Eastern Region. He was appointed to his current position as Senior Vice President-Unit Train Service Group in 1994.

Mr. Dwyer holds a Bachelor of Science degree in Liberal Studies from the University of the State of New York at Albany and has completed the executive management program at Pennsylvania State University. Please join me in welcoming Tim Dwyer.

KEYNOTE ADDRESS

Timothy P. Dwyer

Senior Vice President Unit Train Operation
Conrail

Good afternoon. I'm sure that many of you are aware that this year marks the 20th anniversary of Conrail's birth, creation whatever you would like to call it. On April 1, 1976, the industry got its first good look at this thing decked out in blue that was to solve the problems of railroading in the Northeastern United States.

Well, as Jerry Garcia so succinctly wrote: "What a long, strange trip it's been." Compare today's outlook on business with that of 20 years ago. I'd say the picture has changed substantially since the days when there was still a great amount of uncertainty as to whether this experiment called Conrail would be successful – and beyond that, what the fate of railroads in general would be. Railroads had just been through one of the most difficult decades ever with bankruptcies occurring at a dizzying rate and the industry losing revenue in bucketfuls to trucks.

But after 20 years, we're still here. Whether you consider this fact extraordinary, I don't know. I do. Conrail had every chance to pack it in and take the easy road, the one that led away from the tough choices and the weighty responsibilities and the hard fights. When Drew Lewis said we should be broken up, when Elizabeth Dole said we should be sold to Norfolk Southern, we could have thrown in the towel, said, "Yeah, you're right. We're not up for it anymore." Instead, we chose the hard road, and we're here today because of it.

What have we done to make it this far? As with any business, success comes from making headway on some combination of three issues: Cost reduction, getting better use of your assets and achieving revenue growth that contributes to the bottom line. Conrail has been adept at pulling that first lever – cost reduction. In fact, that has been probably the key to our success over the last 20 years, the ability to accurately size Conrail for the markets that are available to us now. And that has represented a constant struggle since the early 1980s to make Conrail as efficient as possible.

It's happened at other railroads as well, but at Conrail, the task was enormous. Conrail's former Chairman and CEO Stanley Crane has remarked that it was amazing to him that a company that took in as much revenue as Conrail took in at the time he joined the company couldn't bring a single penny of it to the bottom line. At the time he joined the company we were losing, quite literally, one million dollars a day.

Since then, we have become extremely sensitive to our costs, and have made it through some lean times on our ability to ratchet down our expenses when the market turned soft, in many cases, achieving financial goals we had set for ourselves despite the downturn.

And we continue to look carefully at our costs over the long term analyzing where we need to become more efficient and eliminate or streamline processes that do not contribute to the service to customers.

Not only have the industry and Conrail reduced costs, we have had to become much smarter about pulling that second lever: managing our assets much more effectively to

increase the return they provide to the business. This encompasses all of the assets involved in delivering service to customers: track, locomotives, cars, and our investment in information technology.

On the rolling stock side, we have focussed intently on increasing our locomotive usage particularly after it became clear to us two years ago that our motive power fleet was being used in revenue service only about a third of the time. That number is now approaching 50 percent and we intend to have it up above 51 percent by the end of the year.

Our track structure has been slimmed down substantially over the last two decades. However, though we don't own them any more, many of the lines we have shed are still operating – in many cases producing more traffic and more revenue in the hands of short line rail carriers who can focus on the individual needs of customers more closely than a major Class 1 carrier like Conrail ever could.

As much success as we – Conrail and the industry – have had with the first two levers, we need to concentrate now on pulling that third lever, the lever that brings us growth in our revenue base. This is essential. It's our future, not just for Conrail, but for the entire industry. Railroads simply have to begin acting likes companies convinced that they can grow.

We are quickly coming to the point where simply managing our costs and being content to take in enough business to replace what we lose ceases to work for us. And the lightning pace of consolidation that has gripped the industry has little benefit as an end in itself. There is no benefit in efficiency if we cannot use it to increase our traffic and our revenue. We must grow.

We're confident that there are attractive growth opportunities out there for Conrail, this year and in coming years, based on our ability to do three things: To deliver consistent, "no excuses" service to our customers, to provide our customers with a continuous stream of new products, and to help our customers meet the continuing market demand for more efficient logistics services.

First, service quality is critical to our ability to grow. We've heard it from our customers that we can win additional business if we can demonstrate to them that we can deliver the service consistently – make a commitment and meet it day after day, month after month.

Conrail has proved that it can provide a highly consistent service product. For two consecutive months in the spring and summer last year, we did just that for our largest intermodal customer – United Parcel Service. Every single load we moved for them was on time. There wasn't a single service failure during the period. Two months is one thing. Sustaining that level of service day in and day out is another.

That's our challenge and we've been continuously working to improve on our operating plan to address it. The goal: to provide consistent service, to deliver not just on the business that we have, but on the business that we expect that we can win in the marketplace.

Consistency demonstrates to our customers that we've made a commitment to provide a level of service that isn't going to waver day to day based on the changing fortunes of our traffic.

In fact, we followed through on that commitment during the first quarter of this year, despite the tough weather we experienced. We made it our business to recover rapidly from storms and floods, and our customers have let us know their appreciation for that. We kept our service at the highest possible levels while our system was under stress. We believe the reward for that is not only in kind words from customers – we retained the title of best carrier for UPS; and Maersk shipping lines for the third consecutive year has recognized us as its best transportation supplier – not only do we expect kind words, we expect that a commitment to excellent service on our part will yield increasing business from these customers and new customers.

We expect growth.

In addition to consistent service, we expect additional growth to come from new products and expansions of our existing markets. New products can extend the franchise we've built to

markets that offer promising growth, markets like Kansas City, where our new KC Prime intermodal service has been a gratifying success for us so far.

Ultimately, we need to look for partners to extend the limits of our physical system and our service to other geographical areas and other modes of transportation to build a product that can effectively meet the market's demands for logistics services – a total package of transportation and inventory management.

KC Prime is a good example. Conrail's system does not stretch as far as Kansas City, but by forming an alliance with Gateway Western we can provide that service as if it did: Two railroads working as one in the eyes of the customer and building on each other's strengths.

We seek alliances with ports in the Northeast that provide similar benefits. What the port can gain from our expertise and our infrastructure is reach – the ability to extend marine operations potentially one thousand miles inland to reach customers with goods to ship or receive.

Conrail serves all of the major ports in the northeastern U.S. including Boston, New York/New Jersey, Philadelphia, and Baltimore. In each case, we work with the port to get the best from the combination of dock facilities and services in Conrail's transportation infrastructure.

One example of how Conrail can use its system to create efficiencies that bring benefits to the ports on the East Coast is our investment in higher clearances along our main line through Pennsylvania. That project was the largest engineering initiative in our history as a railroad, involving a total investment of $97 million, $64 million by Conrail alone.

The project was completed just last fall, and it is already paying off in new service initiatives and a substantial increase in traffic. This year to date, we have started double-stack intermodal service between Detroit and New York/New Jersey, double-stack service between the Midwest and the AmeriPort terminal operated by the Ports of Philadelphia and Camden, New Jersey; and most recently, our Export Express service between Chicago and New York/New Jersey.

Another example of partnership is our relationship with short lines. Again, I think we've shown real leadership in this area.

This spring, we announced an exciting new partnership program with shortlines called Conrail Express. The relationship with participating shortlines is much like the commercial relationship between major airlines and independently owned and operated commuter lines. We can grow together by plying each of our strengths: The short lines' ability to deliver local service to small shippers, and Conrail's ability to provides efficient, long haul service and manage commercial aspects of the transportation transaction.

Obviously growth is an important part of a successful future for Conrail. But I want to mention briefly one area that we consider to be vital to our success: Safety.

We are determined to operate the safest railroad in the industry and have set aggressive targets to move us closer to that goal. This is important not just to our employees. It is a prime concern of our customers as well, and in our minds we can consider ourselves safe when we've done the job of protecting the welfare of our employees and the public, the condition of our customers' shipments, and the health of the environment in which we operate.

Railroads continue to be the safest mode of ground transportation and we have improved our performance over the past decade. At Conrail, we have focussed a significant amount of resources on reduction of injuries to our employees and damage to our customers' shipments.

Safety is critical not just in and of itself, but for growth as well. Few of our customers would be willing to do more business with a transportation company that they couldn't trust to safeguard their shipments. Nor should we expect them to.

This is just one more reason why I believe the industry – and Conrail in particular – is talking about growth as an achievable reality in the near future.

When we look at the whole picture, what is important to understand is that Conrail's growth, and the growth of the industry aren't necessarily limited by the economy if we aggres-

sively develop the advantages that the rail industry enjoys. We have to be smart. We have to invest wisely. We have to make good decisions and stick with them.

The opportunities are there, and as a company, I think Conrail is more than ready to tackle them. This is what we've worked so hard for over two decades: Rebuilding, shaping, learning, make difficult decisions, chasing a vision of what Conrail could be.

The test of success for our next 20 years is to translate those opportunities again into real growth that makes us a more effective competitor in the marketplace and provides a consistently reliable option for customers and a solid future for our employees.

Thank you very much.

President Bradley: Thank you, Tim. We appreciate that very much.

At this time, it is my pleasure to introduce Mr. L.S. Jacobson. He is vice president and general manager of the Copper Basin Railway and is the Railway Age 1994 man of the year.

To many of you, Jake needs no introduction. I would like to mention that Jake began his railroad career on a steel erection gang on the Union Pacific right after high school in 1958. He worked numerous jobs in the early days and since at that time he had virtually no seniority he was frequently laid off. In between working and being laid off, Jake attended Arizona State University and served during the Vietnam conflict.

In 1969 Jake was promoted to superintendent water service for the Union Pacific with a territory of Kansas City to Denver and St. Joseph, Missouri, to Gibbon, Nebraska. In 1974 Jake went from the engineering department to the operating department and was one of the first chosen from within the company to go through Union Pacific's management training program.

In 1985 he accepted one of the many buy-out programs. He left Union Pacific and went to Cedrite Technologies as a consultant. In 1987 he left Cedrite and moved to Arizona and performed various railroad consulting jobs in the Southwest where one of his jobs was putting together an operating rule book for the Copper Basin Railroad. He hired on the Copper Basin and in July 1988 was promoted to general manager. In 1990, Jake became vice president and general manager. Jake was also instrumental in forming the Arizona Shortline Association and continues to serve on its board of directors. He also served on the board of Arizona Rail Car, which is an advisory board of Rail Car Derailment Detection System of Phoenix.

Jake is a third generation railroader. Please join me in welcoming Jake Jacobson. (Applause)

LIFE ON THE SHORTLINE

L.S. (Jake) Jacobson

Executive Vice President
Copper Basin Railway.

Ladies and gentlemen, fellow track and bridge builders. I was very honored to be asked to come to Chicago and say a few words at the annual conference of the Roadmasters and Bridge and Building associations. As you are probably aware, I have spent 38 years railroading, some were large railroads and some were small. I guess during these 38 years of railroading, I have worked just about all departments from hiring out, to steel bridge gangs, to train service, to track and round house. I have served as an officer in both the engineering department and the operating department. Through these years of working numerous departments across the United States, I have had the opportunity to belong to and be a part of many, many fine organizations and associations. But none has made me more proud than the accomplishments and dedication of the fine folks of the Roadmasters and Maintenance of Way Association and the American Railway and Bridge and Building associations. The people of these organizations have represented for over 100 years the great people of the elite team of railroaders who have saved this nation and saved this nation's railroad systems in time of war, the Great Depression, the floods and the fires and, of course, the recent ice jams and blizzards and hurricanes. The people that these organizations represent, the people right here in this room, are the most capable, durable, and loyal railroaders this country has ever seen. I am just very humbled to be here in front of this elite team of railroaders to talk about life on a shortline.

In 1990, one of our largest shippers, a New York based mining and smelting company was having labor problems. As our railroad has one of their branchlines that runs between their smelter and their mine some 25 miles apart, we became as much a focus of the strikers violence as the mining company itself. Two bridges were burned, our security guard was severely beaten, our trains were shot at, and attempts were made to throw locomotive engineers off moving trains. Protesters laid in the tracks and tracks were sabotaged.

During the winter of 1992 and 1993, the 500 year floods came devastating much of our railroad. The Gila River changed its channel and rerouted itself under our railroad with much of our railroad caving in and being washed away with the raging Gila River. For those of you who have never been down through the river canyon in Mexico and Arizona, this is probably the most beautiful and remote area left in the United States today. Most of it is accessible only by horseback or by rail. There are petroglyphs on the canyon walls and traces of pottery left from the prehistoric Gila people of some 3,000 years ago. Much of this area was old Mexico prior to the Gadsden purchase of 1853.

During the worst part of the flood, a U.S. Army captain and his helicopter crew were assigned to us to help get fuel and personnel to stranded trains and track equipment and to help us get into remote portions of the canyons to assess bridge, track, and tunnel damage. As I looked down from the Army helicopter, I saw rail hanging from 50 foot cliffs, swinging like a pendulum on a clock, and many miles of railroad and bridges under water. With flood waters running through our tunnels, somehow the Gila River Canyon seemed to lose much of its charm and its beauty.

In June of 1995 after five years of heavy rains and lush vegetation build up on the Arizona desert floor from the El Nino effect, we saw the beginning of the first draught in seven years with temperatures ranging from 118 to 121 degrees. With high winds came the desert fires as you saw on national television. The famous White Canyon fire started between Tucson and Florence. Fanned by hot, dry winds and 120 degree temperatures it was over two miles wide when it hit our railroad destroying three large bridges, many small box culverts, tracks, and trestles.

When Joe Lileikis asked me a few months back to say a few words about life on a shortline, we were in the eleventh month of the worst draught in Northern Sonora Desert history. After being shot at and burned up and washed away I was afraid I was going to be more qualified to talk about death on the shortline. (Laughter)

In spite of all the challenges and the years without vacation and some of the back-to-back 24-hour days, I find life on the shortline to be exciting, rewarding and just literally bursting with opportunity. There is no room for politics or Monday morning quarterbacks. Each day I look more forward to coming to work than I did the day before. We truly have replaced the four-letter word "work" with the word "fun".

However, do I miss the Class I railroads? Yes, I miss the hundreds of really great friends and the really great people. When it's 2:00 o'clock in the morning and you have 18 sulfuric acid tank cars that have derailed and taken out part of your biggest bridge, upside down and ruptured, some of them leaking in a river and you are trying to figure out how you are going to fix this with a pickup truck and a pocket knife, you sure miss all those departments and layers of management and environmental and legal advice. (Laughter)

Railroading is railroading, bridges are bridges and track is track. Most of the problems are the same on the shortline as they were on the big railroads. Unfair fuel allocation taxes, exorbitant user fees and more taxes. Cumbersome and costly regulations. Our trains are just as long and they are just as heavy. Our bridges are just as long and the rivers we span are just as deep. Our tracks are just as wide. Sometimes I think our tracks are a little wider. (Laughter)

Just on our railroad alone we will run 22 to 28 trains a day moving everything from U.S. Army tanks to Gatorade. We are just as busy at 2:00 o'clock in the morning as we are at 2:00 o'clock in the afternoon. Sundays are the same as Tuesdays and we move the same tonnage on Thanksgiving as any other day. So any small window of bridge and track maintenance opportunity is very welcome. We plan for days doing as much prework as possible. Our engineering and operating people weigh and cherish every minute of the track and bridge maintenance time window much like a world class vineyard collects and sniffs every drop of vintage wine.

In the shortline business where profit margins can be slim to nonexistent, we just simply have to get the best bang for the buck out of everything that we do.

Once I worked in an environment where our own management was more a part of the problem than part of the solution. They would listen to the yuppies and the whiz kids from the high dollar eastern universities, most of whom didn't know the difference from a spike maul and a shopping mall, but they would put their recommendations and programs into effect anyway. That's how we ended up with the Dr. Hays' Salary Plan. We would fill out the voluminous evaluation forms in the office. We would carry performance evaluations form booklets into the field with the audits being made out in triplicate. We were so busy managing each other we didn't have time to manage our railroad.

Well, on the railroads I manage we hire only self motivators. We hire only people who give a damn. Then we can spend 100 percent of our time and energy managing our railroads and serving our customers. The shortline railroad I manage was actually three separate railroads each belonging to a different Fortune 500 company. One of the Fortune 500s was a Class I railroad. All three were suffering severe financial losses. The Class I railroad was in the process of filing for abandonment. In spite of all the state of the art management techniques, field safety audits, personal performance audits, these Fortune 500s were having 37 on-the-job personal injuries per year. The Fortune 500s and the Class Is that were managing these railroads were losing millions and seeking abandonment. Captive shippers couldn't afford the exorbitant freight rates. There was a disgruntled labor force that was so frustrated that their "give a damn" was broke.

This actually created a golden opportunity. We were able to acquire the tracks and the cars and the locomotives from the Fortune 500 companies and shippers and we were able to acquire much of our labor force from both the shippers and the Class I railroad. I feel that we were better at switching and safety and spotting cars and just working eyeball to eyeball with our shippers and customers. The Class I railroad was better at moving long trains at high speeds over five and six states and across the country. As our customers bought into this partnership, we became more customer driven. The end result was a customer/shipper partnership that now pays 33 percent less per ton than they did ten years ago. There was also the birth of a new shortline railroad which helps keep some of us old railroaders that smell a little bit like diesel fuel and creosote off the streets, and a Class I railroad that instead of losing millions and then seeking abandonment, now backs into the interchange, couples up, ties up their air, and pulls away with over 20 million dollars in annual revenues. There is also a once frustrated labor force that is now part of a profit-sharing partnership that has learned the fun of coming to work when their "give a damn" is not broken. Now if that is not a win-win-win situation, then I guess I don't know what one is.

We must look at everything we do and ask, is it marketable? Some might look at safety and say, "Well, yes. We try to work as safely as possible, but that is not marketable." Consider that the Fortune 500 companies and the Class I railroad that used to manage these railroad properties were having 37 on-the-job personal injuries per year and in 1993, 1994, 1995, and so far in 1996 we have had zero on-the-job personal injuries. When you also consider the legal fees and the lawsuits and the skyrocketing insurance costs then safety becomes very, very marketable. All of these costs are having a direct affect on the freight rates.

As I reviewed the railroad statistics on safety, I was very proud of each of you with injuries down 20.78 percent and fatalities down 50 percent. I think that is the best improvement ever recorded and the vast majority of credit belongs to you.

I have a definite opinion of what safety is and I will do my best to share that opinion with you. Safety is a group of alert, caring people working in complete harmony with the ever-present dangers of moving equipment, obstacles, chemicals, and electricity. Safety is the art of mastering all hazards of rules, rule compliance and procedures, common sense, and a people with a deep concern for their own wellbeing as well as a respect for the wellbeing of their coworkers.

My father was a bridge man. My grandfather was a track man. Between my grandfather and my father and myself, we have 115 years of railroad service but not one with on-the-job personal injuries. A few months back, Joe said, "Jake, everybody in the railroad business knows you. When you come to Chicago, will you tell us the smartest thing you ever did?" I didn't have to think long. It was 1963 and I was working in the water service at the time. The smartest thing I ever did in my life was to marry Patricia 34 years ago.

Another smart thing I did was bring myself home from the military service in one piece in the troubled times of the mid 1960s. Another smart thing I did was in the late 1960s and early 1970s when I was a young maintenance-of-way officer working between Kansas City

and Denver and St. Joseph and Gibbon, Nebraska. I noticed a young draftsman working in the industrial engineer's office. This guy was a hard worker, had a "can do" attitude and was definitely brighter than the average bear. I mentioned his talents and potential to the superintendent and to the division engineer and to the district engineer. A few months passed and our railroad decided to build seven new state-of-the-art automated one spot rip track building facilities between California and Kansas City. The one in Kansas City was going to be in the most difficult location. It was down by the old cleaning tracks and switching tracks. This was a poor drainage area and every place you tried to dig you hit more old foundations and manholes and abandoned sewer lines and rail. This location was an absolute nightmare mud bog with a spaghetti patch of some live and some dead pipelines.

Some of the local engineering people that this project would have naturally fallen to became ill and others came up with 101 reasons why they couldn't be running this job. So it really wasn't much of a promotion, but the hot potato that others were afraid of got dumped on the rosy cheeked and somewhat naive young draftsman. I was quite extensively involved in this construction project and I had two of my best foremen and two gangs assigned to it.

I was having trouble with our turning span bridge over the Missouri River at St. Joseph, Missouri. It was always a challenge to keep peace with the barge traffic and Corps of Engineers when this old 1917 bridge would break down half open stopping both barge traffic and train traffic.

Upon returning from the St. Joseph bridge dilemma back to the Kansas City one spot rip track project in the rain, I found the once rosy-cheeked draftsman, now the dirty-faced project engineer with mud running over the tops of his knee-length rubber wading boots. He was frantically trying to keep half a dozen sludge pumps running while they were dragging, sucking, and slobbering hoses to the lowest spots while forms were giving way and sliding into the trenches. And then another half a dozen concrete trucks showed up with the men saying, "Where do you want this?"

Well, to make a long story short, this new baptized-in-mud project engineer never quit. The tougher things got, the earlier he came to work and the later he stayed and the more four-letter words he added to his repertoire. In spite of all the mud, the challenges, and the obstacles, this new project engineer brought this job in ahead of schedule and under budget.

Years later after I had left my officer job with the engineering department and took a new job as officer in the operating department at another location in the Midwest, we were planning a major consolidation and office relocation and expansion. The man who showed up to handle the job was none other than the once rosy-cheeked naive draftsman. He had worked many years as a bridge and building supervisor out west and now standing in my doorway was the weathered face of confidence and the stature of a man who had learned his discipline well but with the same warm smile of the draftsman from days gone by. I realized that one of the smart things I had done in my career was recommend this fine person for promotion.

Union Pacific Railroad knows this man as one of the most outstanding and dedicated officers. I know him as friend and fellow railroader. Many of you know of him as the past president of this fine Bridge and Building organization, Mr. Don Steele.

Through the mergers and the buyouts and the streamlining and the acquisitions and consolidations, we have all seen a few sunsets and have had to move on to new horizons. It seems as though I have left a trail of friends from both large and small railroads all across this nation. It is very refreshing to be here and see so many friends from days gone by and some I hadn't seen since I took a buyout from a Class I railroad ten years ago.

With the new rounds of mega mergers, I am sure many of you will be looking at considering the possibilities of a buyout. Well, as a veteran of this dilemma, I can tell you that you never really know how poor a job you are doing until you see how much they are willing to pay you to leave. (Laughter)

All humor aside, I am very concerned by this mega merger mania that has been sweeping our industry. Is it good for our industry as a whole? I guess sometimes I feel like I have

lost the ability to distinguish the difference between good news and bad news. With all this downsizing and uncertainty it's difficult for everyone. I think the biggest burden falls on the shoulders of engineering, track, and bridge and building people. We are the ones who convert and maintain 100-year-old bridges and structures and track for today's high demand usage. We are the ones who design and plan and build the bridges and track and structures that will serve this great nation 50 and even 100 years from now. We, the engineers, the track, and the bridge and building people are by the nature of our disciplines forced to be long-term thinkers in a short-term environment. We daily are making 5, 10, even 50-year decisions, yet it seems like we are trying to dance to the beat of the drummer who is governed by Wall Street and lives from one quarterly financial report to the next, merging railroads and spinning railroad properties as if they were hot dogs at Wrigley Field.

Sometimes they have a tendency to make forced reductions in the disciplines they know the least about which usually ends up being engineering, track, and bridge and building with little regard for deteriorating infrastructure. With each round of downsizing engineering staffs requiring higher levels of employee productivity, sometimes I am afraid we are reaching the point of where my rule of pi and doughnuts takes effect. That's when each time you try to enhance profitability you make the hole in the middle of the doughnut a little bigger. There comes a point, however, of critical mass or meltdown. That's when you take pi or 3.1416 times the diameter of the hole in the middle of the doughnut and that figure exceeds the outer circumference. You now don't have any doughnut left. (Laughter)

I have mixed emotions when I read about the planned merger of our associations. My father, Myron Jacobson, built railroad bridges for 47 years and belonged to the fine Bridge and Building organization for many, many years. I have belonged to the Bridge and Building organization for many years as well as the Roadmasters Association back in the 1960s and 1970s. Reluctantly, I understand as our railroad industry continues to be deluged with more and more cumbersome regulations, with bureaucrats enacting more and more laws and user fees and taxes so they can hire more and more regulators and bureaucrats, the railroads will have to continue to get rid of those fixers to pay for the new waves of government finders, taxes, laws and user fees. Therefore, the vicious cycle of downsizing engineering staffs has continued and now the supporting organizations have no choice but to change to reflect the new limitations on budgets, time, and to avoid duplication. I guess the good thing about the merger of these organizations is it couldn't have come at a better time.

We are blessed to have the wisdom and the talents and the energy of bridge and buildings' Mike Bradley and Joe Lileikis, AREA's Jim Beran, and maintenance of way's Ken Koff and Wayne Russell to guide us through these difficult times. With the support of all of our members, I am confident that our task force will put together the association of all associations. You know, the shortline railroad industry is an interesting melting pot of railroad people. Just on our line we have had the benefit of knowledge of people from the Santa Fe, Kansas City Southern, Missouri Pacific, C&NW, Texas Pacific, Union Pacific, Rock Island, Southern Pacific, Baltimore and Ohio, the Prairie Central, Kennicott Railroad and the Illinois Terminal Railway. When we have a problem, we gather solutions from all these railroads and we keep only the best. With this spirit of putting the best of these great organizations together, I am confident we will see a win-win-win conference showcase in 1998. From our combined talents in this room we can build any kind of track to go anywhere. We can build bridges of iron, bridges of wood, bridges of concrete and stone. We can span any river, any canyon, any swamp and any void.

But we must build a new and different bridge. This bridge must span uncertainty, doubt and past prejudices. The bridge piling must be made of integrity and good deeds, the caps of wisdom and compassion, and the stringers of fellowship and understanding. The bridge decking and track must be made of honor, dignity and respect for all disciplines.

Only from these ingredients can we build a bridge of all bridges – the bridge of unity. This bridge of unity must be completed in the next few years as it must carry the fastest and most

powerful train of all. It must carry the train of thought into the 21st century. We will need the power of technology and communication. We will need locomotive power for our work trains. We will need the power of diesel and hydraulics to drive our pilings and set our stringers and to build our tracks. But our real power to build this great bridge of unity to carry the train of thought into the 21st century is in the pride of our people. Thank you very much. (Applause)

Mr. Bradley: Thank you, Jake. At this time, we will take a short recess and reconvene back here at 10:15. (Recess)

Mr. Bradley: Our first presentation this morning is the design, maintenance, and repair of bridge navigation fender systems and will be introduced by Rich Calhoun, director of the B&B Association and an associate for CTE Engineering.

Mr. Calhoun: Thank you, Mike. At this time it gives me great pleasure to introduce Mr. Frank Martin, chief of the permits division, and Mr. Roger Wiebusch, western rivers bridge administrator, both of the U.S. Coast Guard department of transportation.

Mr. Martin of the headquarters office in Washington, DC, has had a wide and varied 32-year career with the U.S. Coast Guard. His assignments have given him a wealth of experience in the field of federal program management and the administration of public policy. He has served with distinction in both the military and civilian side of the service both afloat and ashore.

From the mid 1970s to the early 1990s, Frank was a government leader in the policy development and federal program administration concerning oil pollution liability, financial liability, and compensation issues affecting the U.S. outer continental shelf and deep water ports. Since 1992, he has served as chief of the permits division at the U.S. Coast Guard, headquartered in Washington, DC.

Mr. Wiebusch of the district office in St. Louis directs and oversees all aspects of the Coast Guard's bridge administration program within a 22-state area that includes 7,000 miles of navigable rivers and 1,200 bridges. He is a 1970 graduate of the University of New Hampshire and a 1971 graduate of the U.S. Coast Guard Candidate Officers School. He was then assigned to seagoing wheat tenders in Juneau, Alaska. After briefly leaving the Coast Guard in 1975 with the rank of captain, Mr. Wiebusch worked for the Corps of Engineers. In 1983, he rejoined the Coast Guard and assumed his current position. Please join me in welcoming Mr. Martin and Mr. Wiebusch for this informative presentation. (Applause)

THE DESIGN, MAINTENANCE AND REPAIR OF BRIDGE NAVIGATION FENDER SYSTEMS

Frank Martin

Chief of Permits
U.S. Coast Guard
Washington, DC

Thank you for the nice introduction. We are privileged to be here today. Good morning everybody. Thank you for inviting the Coast Guard to speak about Bridge Administration Program particularly about bridge pier protection and fendering systems and their design maintenance, and repair.

Mr. Mpras, the national program manager for the Bridge Administration Program, was unable to attend today due to scheduling conflicts. He was looking forward to personally making this presentation. However, he ended up in Alaska this week to work on very important Coast Guard bridge permitting issues associated with the new trans-Alaska gas pipeline with its many river crossings up there.

Nevertheless, I am pleased to be here and act on Mr. Mpras' behalf to make this presentation. We appreciate this opportunity to be a part of your convention agenda and to interact with you. My presentation will give you an overview of the Bridge Administration Program and fendering policies from a national perspective. I will be followed by Mr. Wiebusch, our well qualified and highly experienced bridge administrator from our Western Rivers office in St. Louis. Roger will speak to you from a river perspective on commercial marine traffic and bridge fendering systems.

To the mariner, a bridge is viewed as an obstruction to navigation and therefore a possible hindrance to a safe passageway. When Congress enacted the Bridge Statutes their intent was to retain exclusive federal jurisdiction over the navigable waters of the United States. The purpose was to prevent the impairment of public navigation. The Army Corps of Engineers until 1967 administered the bridge statutes. Concurrent with the formation of the Department of Transportation in that year, the bridge administration function was transferred to the United States Coast Guard.

As we carry out our legal mandate, we work to ensure that bridge projects balance the reasonable needs of both navigation and land transportation while maintaining compliance with applicable environmental control laws. This is done primarily as follows:

First, Coast Guard approval of specific location and plans for the construction and modification of bridges. This is our bridge permitting function which includes bridge pier protection fendering systems and ensures that horizontal and vertical clearances are adequate for existing and future navigation.

Second, requiring, where necessary, bridge navigation lighting, clearance gauges, and other markings for safe navigation and the protection of the bridge facility.

Third, regulating draw bridge operations openings and closings.

Fourth, alteration or removal of bridges determined to be unreasonable obstructions to navigation. Generally this occurs when waterway conditions change or the character and size of navigation passing the bridge site changes.

Finally, to ensure that bridges and approaches conform to the environmental and human resource laws and regulations and that all prudent and feasible actions to minimize harm or takings have been considered when developing bridge projects across navigable waters. The Coast Guard as a matter of law does not concern itself with structure adequacy of bridges, pier protection, fenders, or any other accessory works. This matter is normally left to the bridge owner to work with the local regulatory bodies which establish and enforce construction codes.

The Coast Guard also relies on the principle of law which places the burden on the bridge owner to ensure that the bridge structure and its appurtenant pier protection are adequate for their intended purpose. Whether or not that adequacy is there during a vessel hit or following is a matter between the bridge owner and the vessel owner to be resolved in civil court if such remedy is needed.

For the safety of navigation, bridge facilities, and land transportation interests using bridge structures to cross over the navigable waterways, the Coast Guard carefully considers the need for bridge pier protection fender systems for all new bridge construction, modification, and replacement projects. If the design of a bridge is such that it has piers in the waterway which are adjacent to main shipping channels and thereby are vulnerable to being hit by commercial marine traffic, fendering will be a mandatory condition of the authorizing Coast Guard bridge permit. A perspective fendering clause will be used when fendering is not determined essential at the time of initial construction, but could be needed later as a result of future waterway channel improvements or port development.

In those cases where waterway piers are specifically designed to withstand vessel hits, fendering may not be needed. However, the Coast Guard may still require nonsparkling surfaces to minimize or prevent the risk of an explosion from contact by vessels or tankers carrying volatile liquids. These pier fendering policies are applied equally to highway or railroad bridge crossings.

The Coast Guard does assist bridge designers by providing the knowledge of the local waterway necessary to promote safe navigation at the bridge site. In addition, this kind of information will lessen the danger of vessel hits to the bridge and its accessory works. When considering proposed bridge projects, we give the mariners an opportunity to comment sharing their experience and knowledge of the waterway with us, the bridge owner, and the designer. This knowledge used during the bridge design can provide an economic benefit to the bridge owner of reduced maintenance costs. For example, there may be reduced cost of fender repairs due to many repeated ship and barge strikes.

The Coast Guard prefers to be involved in the early development of bridge projects to assist bridge owners in determining the best course of action for building, modifying, or replacing a bridge and providing advice as to the need or desirability of bridge pier protection systems. We will not act as the architectural or engineering consultants, but we will provide information necessary to meet the reasonable needs of navigation especially when we are discussing such items as navigation span location, clearances, and fendering as they apply to navigation and the flow of the waterway. Early discussions should take place between us and the bridge owner concerning the alignment of the navigation span to the waterway, the location of the bridge as it impacts navigation such as a bridge on a bend of a river or misalignment of navigational spans with existing adjacent structures, fender alignment, and much more.

Appropriate response to all these issues can save the bridge owner the costly expense of reengineering at a later time and minimizing the risk of vessel collisions with that bridge.

The Coast Guard, as case law stipulates, does not concern itself with such matters as character and tensile strength of all materials used in the construction of the bridges and its appurtenants. However, as the statutes do provide and as court precedents have been applied, we are concerned with the manner and construction of a bridge and its appurtenants as they affect public navigation. It is of little use to prescribe adequate and safe navigational clearances if the vessels passing through the bridge are subject to danger because of the bridge design, construction or use of faulty material.

For example, we probably would not allow steel rub rails on fenders in a waterway where the usual vessel or barge traffic contains flammable, combustible products or other hazardous materials.

I can't emphasize enough that the issue of bridge fendering and safety at bridges at the intersecting points of bridges and navigable waterways is a matter of high priority and concern within the Department of Transportation and at Coast Guard headquarters. The issue is of such concern to the Coast Guard that one of the main Department of Transportation strategic transportation goals is a safe, efficient transportation system for all the modes of transportation in the nation; railroads, highways, and waterways. Wherever there are intersecting modes of transportation such as railroad bridges crossing navigable waterways, the Secretary of Transportation himself and the commandants feel very strongly that we should work diligently to make sure that these intersecting points are safe for the bridge, safe for navigation, and safe for land traffic crossing over the bridge.

After a bridge is completed, we are concerned that safety be maintained for the mariner, the bridge, and its appurtenants. The bridge owner is responsible for and must properly service and repair fender systems, navigation lights and other markings such as reflective panels, clearance gauges, and so forth. Further, draw bridge openings and closings must be as prescribed. The bridge owner is responsible to do whatever is reasonably needed to maintain the authorized permitted clearances for safe navigation through the bridge.

We are concerned with anything related to bridges which affect safe vessel passage through or under the bridge. The bridge owner's responsibility for good maintenance and proper repair to bridge fenders, lighting, and marking systems is a matter of law required under the bridge statutes. These issues have been well established to be within the scope of the Coast Guard jurisdiction over bridges across navigable waters of the United States.

I will conclude this part of our presentation with the following thoughts. The Coast Guard has a mandate to provide for the reasonably unimpeded navigation of this nation's waterways and that is also to be sure that the safety is emphasized wherever needed. We need and desire the open and free-flowing information exchange with you, the bridge owners, as early in the process of designing the bridges and appurtenants as possible. We believe such early communication and coordination may save you considerable cost in time and money by eliminating the need to reengineer later in the process when you are actually ready to build, modify, or replace a bridge. At the same time, we wish to ensure a bridge and transportation structure which will meet the reasonable needs of both water and land transportation interests.

Thank you again for inviting us to be part of this conference. (Applause)

Mr. Wiebusch: Good morning. I will present the second half of the Coast Guard presentation. As stated, I am Roger Wiebusch. I am the bridge administrator for the Western Rivers Area of the Eighth Coast Guard District. Like some of you, the Coast Guard has undergone some streamlining, downsizing, rightsizing, or whatever the proper term is and the Second Coast Guard District which I used to be part of is now merged with the Eighth District and I am proud to be there.

It is known as the western rivers by the Coast Guard and involves 7,000 miles of navigable waterways, 1,200 bridges, and touches 22 states. This area also has the unofficial distinction of having the most reported hits between commercial vessels and bridges. Since 1972, there have been over 3,600 collisions or hits between vessels and bridges. A high number of these have involved railroad bridges and an even higher percentage of these have involved railroad swing span bridges.

Now before I get too far into the talk, I want to talk about some common definitions of different protection devices and different terms I am going to be using. A hit basically means any contact between a vessel and a bridge. Whether there is a lot of damage or a little damage, rubbing, scraping, knocking things over, et cetera, it's a hit. A protection system is all the structures whose purpose it is to help protect the bridge and to prevent the direct contact between the vessels and the bridge.

In this case we have a shear fence that runs through the span. We have a protection on one side and we have a dolphin on the other side. Collectively, this whole thing would be the protection system and there is going to be a similar one on the pier.

A protection cell is just that. It is usually a round, steel sheet cell filled with rock or some kind of material. It usually has a concrete cap. These are usually on the upstream side of the bridge although sometimes they are on both sides of the piers.

An ice breaker is kind of an antiquated protection system on bridges that were built in the early part of the century. Its purpose was to break up the ice before it hit the bridge so as to protect the bridges piers. There are still some of those around.

A dolphin is basically a series of pilings that are driven into the river bottom and tied together with some kind of a cable to keep them together as a group.

A shear fence is just a fence of timbers that extends upstream or downstream from the bridge span. It can be of different size timbers, but it does provide a fence. Vessels sometimes use that to guide themselves through the bridge.

A bull nose is a big steel protection cell that is on the upstream or downstream side of the pivot pier protection on swing spans.

The pivot pier protection system is a system of a bull nose or some kind of cell on one

end, and a shear fence or timber fence that runs between the bull nose and back to the pivot pier of the swing span. That is both on the upstream and downstream side of the bridge.

This is another kind of a pivot pier protection system that is kind of unique and occurs on one of the rivers that we have. It is basically a series of cells that were built between them. Although there is a lot of space there, usually a shear fence implies there is more structure than space. However, in this case there is not a really wide member on the shear fence, but they constructed a series of cells from the bull nose back to the pivot pier on both sides of the bridge. It serves very well to keep these off the pivot pier.

A barge or a tow is basically the type of commercial vessel that operates on the western river. It is on the river system. It's a tow boat in the back pushing a series of barges. Each barge is lashed together. It is made up to be any size depending on the river. Generally north of St. Louis on the Mississippi River there are about 15 barge tows, five long, three wide. Below St. Louis, you will find there are 30 barge tows usually. Different rivers are designed for different size tows. It is pretty well dictated by the size of the locks and dams.

Now, let's talk about the design of protection systems. A bridge protection system is a group of structures designed to prevent direct contact between vessels and bridge piers. In performing this function they also serve to assist vessels through the bridge span. As Frank previously stated, the Coast Guard's concern and contribution is from the navigational standpoint, not structural. We will assist you in providing information considering what type of vessels can use the waterway and where the navigation problems are through that area. However, we don't get involved with the structural aspects of designing the protection required.

From my standpoint I think there are seven factors that contribute to appropriate design of protection systems. They are as follows:

1. Pier location.
2. Pier or bridge permit history.
3. Type of waterway traffic.
4. Waterway characteristics.
5. Type of bridge.
6. Navigational span characteristics.
7. Type of pier construction.

Now, first regarding pier location. I think the single most important factor to consider in whether or not a pier protection system is needed is where the pier is located. For new bridges that you build, the Coast Guard can and will tell you where the piers should be. By appropriately locating the piers we can lessen the chance of collisions with vessels. Primarily for the fixed bridges, we have wide spans. For existing bridges and movable bridges, the channel piers are at the greatest risk to vessel contact and damage. Any pier in the river has a chance of being hit by a barge or loose barges. The greatest risk is always to the piers adjacent to the channel.

Once the high risk piers are identified it then becomes an issue of deciding what type of structure is needed to protect them from the type of vessels that operate in the area. The bridge permit history is important because what we see is that when the bridge is originally constructed and permitted the type and location of protection is identified. A lot of your bridges, especially your swing span bridges, were permitted in the late 1800s or early 1900s and the type of vessels that operate on the river were a lot different. The size and navigation openings are much smaller than what would be acceptable in today's traffic. As a result, certain types of protection were designed and put in place to basically protect the wooden vessels carrying passengers from being damaged by your concrete and steel bridges. As a result, on these permit plans we see a lot of shear booms or floating logs that would help vessels get through the bridges. Over time, the shear booms were replaced by shear fences which are more substantial. Then the shear fences were replaced by more substantial cells to better reflect the fact that the type of vessel that needs protection has changed. Also is the fact that perhaps now your

bridge is more vulnerable to damage by the vessels so the protection structures have to change. The type of structures change, but the location stays the same.

On this Louisiana bridge, as a tow goes through there are some interesting things to note. There is no pivot pier protection on the upstream side and there should be some. The permit requires it. The permit also requires there to be a rock-filled timber crib that extends hundreds of feet upstream of the bridge.

This is the status of the rock-filled timber crib in the mid 1980s. As you can guess, any kind of structure like that on the river where you have big tows, big barges coming through, a lot of ice on the river and these things are going to get damaged. It is a maintenance nightmare for the railroad. It was always under disrepair. We were always hassling the railroad about getting this thing fixed. The barges were always running aground because they could never tell where this thing was. It was a real problem.

In order to solve that problem the railroad came to us and said they really would rather not have to repair this thing or replace this thing. We coordinated the needs of navigation. The railroad and ourselves and navigation industry said we can replace this. This isn't critical, but this is the remains of an old protection system that was required 70 years ago when this bridge was built. Now it is time to move ahead and get into the modern era. So we replaced that with a series of concrete or steel sheet pile cells lined up in the same alignment pretty much of the fence but shorter to the bridge and closer to the bridge. We replaced the rock-filled crib with these cells that can be maintained. They are not a maintenance problem and it helped the railroad.

We don't mind and in fact we like to get rid of protection structures that no longer have a purpose or a function. If something is high maintenance and serves no purpose, we don't mind getting rid of it. We can replace it or identify what kind of structure should be in place to improve it from your standpoint.

The protection system's design must be based on the current situation and the threats. You need to put adequate structures in the proper location and not just perpetuate structures for no reason. Some structures can be eliminated and we have done that at Louisiana.

At the Sabula bridge on the Mississippi River, there is a long shear fence that extended hundreds of feet upstream of the bridge. Following a pretty good collision between a tow boat and that fence that wiped out several hundred feet of the fence, we determined that the part that was destroyed really wasn't needed. Again, working with the navigation industry and the bridge owner we determined that we really didn't need to replace the whole fence. The only functional part of that fence from a navigational standpoint was the top 200 or 300 feet. So we just required this portion of the fence to be rebuilt, put a substantial dolphin up to support it, and the upper 200 or 300 feet of the fence that didn't serve any purpose and was already destroyed really didn't to be rebuilt.

So, again, the bridge owner could benefit by eliminating some of the structure that is just a maintenance headache and actually served no purpose to the navigation industry.

Now, a third item of concern to design bridge protection systems is the waterway traffic. We talked a little bit about barges and at least mentioned the barges and the tow zero here. If there is a close fit for the tow to get through the bridge, what is important to consider in designing a protection system is again the size of the tow. What is the biggest tow? Three wide? Five wide? Two wide? How big an area is this tow going to occupy going through the bridge? Obviously with that is how big are the barges? A typical barge is 35 feet wide and 195 feet long. The capacity of loaded barges is 1,500 tons each when they are fully loaded. The tow boats will vary in size from 700 to 800 horsepower being 20 by 40 feet to the 4,200 to 6,000 horsepower boats being 145 by 40 feet.

Regarding tow boat speed, as a boat approaches your bridge a lot of its speed is going to depend on what the river is doing. It is not uncommon to have a river current that is going seven to ten knots. To increase your maneuverability in the boat you need to be going faster

than the river. So these boats are going to be coming at a pretty good speed toward the bridge during high periods of water.

Another thing is how frequently do the boats come. Most of the waterways that we deal with in the western river area have year-round navigation or at least nine months out of the year. The Mississippi, the Missouri, and some others close down for about three months out of the year, but for the most part all of the other waterways are year-round navigation.

Factors also to consider concern the waterway traffic is high water if they use helper boats. How do they get lined up for the bridge?

Regarding waterway characteristics, a navigation chart is what a mariner uses to travel up and down the river. There are a lot of issues involved for the mariner. All rivers have established navigation channels that lead to the bridges. The bridge is obviously a navigation span. In some cases, the navigation span is really the determining factor of where the navigation channel can be. The boats can go bank to bank in many reaches of the river, but they have to be lined up to certain areas in order to get through your bridge. The channel locations and the path the vessels will take will change as the current and the river levels change.

This is especially true with some fixed bridges on the Ohio River. During normal river levels the tows will use one navigation span and run one part of the river. At high water they will run the opposite side of the river and run different navigation spans. The river levels will dictate where these boats are going to go. It is not uncommon in the western rivers system for the rivers to change 20 to 30 feet during a navigation season between high water and low water. This obviously impacts river velocity, vessel speeds, and approaches. High rivers also usually cause cross currents that affect the tows just as they are trying to get through your bridge. They push the vessel sideways into your piers.

One thing also that affects vessels as they approach the bridge is the angle that they are going to be when they get to your bridge. Ideally a tow would like to be parallel to the flow of the river going through your bridge. Ideally your piers should be parallel to the river flow. This is not always the case. Tows do approach and pass through the navigation spans at an angle.

In this case, the bridge span is around the corner. The boat has to get around the bend and get through the span. It is not easy to do and keep them straight. In this case going through a span it's still not perfectly parallel with this protection system. It is at an angle. The bigger the angle, the greater the chance that the vessel is going to contact your bridge. It may hit the bull nose if it is running a span on the other side. It may have to touch it, pivot around, and get lined up to get through the bridge. The angle is really critical. If it can be straight to the bridge it can get through fairly easily, but it is very difficult to do with all the factors that always affect the passage of the vessel.

The type of the bridge is important. Fixed bridges usually provide greater navigation opening than the movable bridges. Fixed bridges also usually have more than one navigation span. The movable bridge is more likely to be hit especially the swing spans because they provide such a narrow, restrictive opening. Typical waterways in the western rivers have a maintained channel of at least 300 feet wide. The swing spans, the lift spans, the different movable spans that we have typically are only 150 feet to 200 feet at the most. They are very restrictive. The tows are used to operating at least at 300 feet and then they are cut down to a much more restrictive opening.

One of the things that is important also with the angle and with designing the protection system is the gap that exists between the cell and the pier and the dolphin and the pier. If possible you want to eliminate these gaps. There is a little shear fence built in. If you have a bridge where the vessels have a sharp angle of approach, the corner of the barge is going to get caught in the gaps, they are going to rip up the protection cell, the barge is going to break loose, and it's going to be a mess. In designing the system in the span itself, try to eliminate the gaps where the tows are going to get corners of the barges caught.

Stone piers are old and have been there a long time. This is a bridge that was hit and seriously damaged by a tow collision. Again, the pier was old and it wasn't able to withstand the hit of the barge. After the repair work it is, but again one of the concerns you should have is the type of the structure as far as whether or not the pier that you have out there can withstand the hit from the vessel and the tow that is moving at it.

I would like to talk about the maintenance of protection systems. The very nature of the bridge protection means that it is going to be hit and damaged to some degree in order to achieve its purpose. Protection structures must be properly maintained in order to serve their intended purposes. As a bridge owner, it is your responsibility to properly maintain the protection structures since they are considered part of the bridge. The type of maintenance varies depending on the type of structure.

We, at the Coast Guard and my office, can be reasonable with the bridge owners as far as when does this have to be repaired or maintained? How quickly does it have to be fixed? A lot of it depends on the nature of the damage and where it is.

In this case, this is a good shear fence. The cell goes back through the pier. Timbers line the fence keeping the vessels off it. A typical shear fence doesn't just fall down after one hit or one bad season. But through a series of long neglect, a bridge will get to the point where the thing totally collapses into the river. They should be periodically looked at to make sure they are still in good shape.

One thing to concern ourselves about is the shear fence and all kind of debris and drift that becomes lodged between the whalers on the shear fence. If it sticks out in the river, it's going to damage vessels. If a vessel hits this, it is also going to rip off the shear fence. Again, if you have shear fences that have big gaps in them, you have to make sure to keep the debris cleaned out. Obviously at a flood stage if this stuff is getting stuck in there we are not going to tell you to go out there and get rid of it. But after the river has come down to normal level, it is something that needs some attention and needs to be taken care of.

We don't care about the cosmetics of a cell so much as far as whether it's rusty or white or blue or any other color, but it looks like a cell. It is permitted to be round and it looks round. If a cell has lost its steel, you can see all the concrete on the inside. Concerns about this would be the jaggedness of the steel that would be exposed to the vessels and hitting this. Eventually this is going to fall out into the channel. Again, some maintenance is needed here to make sure that it is properly maintained and it is not going to be a problem. It is still going to protect the barge and the bridge.

Here we have a cell with a tree or a big weed growing out of it. Sometimes these cells get hit and they get cracked and stuff starts growing out of them. It is not good and typically it's just going to wear on the cell and deteriorate the cell and block the navigation lights. It's something that we want to see gotten rid of.

This is a pretty well damaged, messy protection system. There is a steel sheet pile cell here, a hunk of the steel is gone, and concrete is exposed. Steel fencing is nonexistent. The whole thing is damaged and dented. It is really a hazard to navigation going through this. As in most cases when we call you up as bridge owners and say there is something wrong with your bridge or you need to fix a cell or a fence or something, you have always been very cooperative and react as soon as you can.

In this case, this is the same structure after all the repairs have been done.

This is a concrete structure where there was a forerunner to a protection cell on the Cumberland River. We have monolithic concrete, but if you look at the bottom you will see it is all beat up from barges hitting it. On the bottom it is really corroded away.

At some point damages to concrete structures stop being cosmetic and start being structural. We see these things and we say, "Well, how bad is this? Is this a concern yet?" If rebar or steel rods or anything else start showing, we get really concerned. If these things continue to get eaten away, we get concerned a lot more that something needs to be done to replace this.

At this point here, we come to you as a bridge owner and say, "How bad is this? What do you plan to do with this? Should this be repaired now or at what point should it be?" Again, structures on the river are going to get worn away. They are going to get beat up. As tows hit these things, repairs are going to be necessary.

If you take a concrete pier, line it with wood as Frank was talking about not having a contact between the vessels, the skin of the barges, and the pier sometimes, this is an excellent way of ensuring that we are not going to have any problems with spark-producing activity if the barges do hit the piers.

Again, we would look at the bolts that hold these on so we don't have any steel sticking in the river to open up the barges.

When determining whether or not shear fences should be repaired or how often is it critical usually timbers near the top are really important in any areas that barges are going to operate in and come in contact. We realize that if you are missing some timbers down near the water level it's going to be more difficult to replace. You may have to wait until the water goes down. It may be a seasonable repair that is necessary. We can be reasonable and work with you as bridge owners to identify when the best time is to fix something.

The main thing is that you realize that there is some maintenance going on and that there is some inspection. Something needs to be done and there is some plan to do it. If it becomes a critical nature that really threatens what we consider to be the integrity of the bridge or the safety of the bridge then we will get more insistent that something get done right away. This is especially true when it starts getting down close to the pivot pier. If one or two barges constantly wipe out all the timber and the pivot pier starts to become naked, I think most of the time when that happens you are really good about calling me up and telling me how unsafe the bridge is because of what the barges did to it. You know we need to do something to make sure that it is fixed right away.

Again, a shear fence definitely needs some work done up here. It was smashed. Whatever structure was here was just wiped out. The horizontal members are missing. Some of them that stick into the channel become a real hazard. This needs to be fixed. We would be more insistent that something be done up right away than if we were just missing a few timbers on the horizontals.

This is a protection cell. It was a highway bridge. Again, this used to be vertical. One day a barge came down and hit it and permanently tipped it back to the pier. This does need to be repaired. What happened here is we needed to repair this. It wasn't possible to rebuild this thing. Taking it out and building a new one would start encroaching into the already restrictive horizontal opening. So they went upstream with this pier and built a new one. In order to ensure that this same damage didn't happen again, they tied the cell into bedrock with steel poles running up it fairly frequently. It has suffered some hits but the cell was never moved after it was tied in very strongly down to the bedrock.

Notice also in the bridge span they do have timbers mounted horizontally again as rub railings through the span.

When you are doing repairs to your bridges after we tell you they need to be done, I think it is important that you realize the boats are still going to be coming through the spans. You have to tell us what you plan to do, when you plan to do it, and how it is going to get done. If there are work barges that you are going to have in the navigation channel, we may have to require them to move for the passage of vessels. Again with a swing span, it might be that the span is not used a lot and boats can still come through. Occasionally we don't have a problem with giving you so many hours closing the spans of navigation to give you four to six hours of work if you need to do that. Ideally we try to keep the span open at all times and require the contractors to move. It is vitally important that you tell us what is being done so we can take a look at what you are doing. You can't decrease the horizontal opening of the span very much and we need to ensure what you plan to do is within the guidance of the permit.

A nonstructural item to increase the navigation safety is lighting or light marking of bridges. We will have lights on the cell and lights on the bull nose. Lighting, marking, and all these nonstructural ways to improve the protection of the bridges are critical. The district commanders will describe what lights are necessary, what markings, and pier protection lighting, retroreflective panels, painting, or anything like that in order to make the pier stand out. The idea is that if the vessel operators can see your structures better from a mile away they are going to have a fighting chance of missing it.

In summary, I would like to say the main thing, as Frank says, is we want to work with you as bridge owners to basically do things that are reasonable and make sure things are safe for your bridge as well as for the mariners who use these bridges. So talk to us and tell us what is going on. We don't have a problem getting rid of protection structures that are not necessary. If you can save money on maintenance and we can make the water safer by eliminating something, we are all for it. You have to talk to us. You have to tell us what is going on. We will work with you. We will coordinate the issues with the navigation interests and find out what can and cannot be done.

In closing, regarding bridges from a navigation standpoint, we realize that you get to use your bridges once in a while to run trains across. So we know they are there. We realize that is their purpose and we fully realize the fact that you get a chance to use the bridge. We don't mind holding boats up for you to use your bridge because that's its purpose. Again, we want to work with you.

If you have any questions, please contact the appropriate Coast Guard bridge office. Frank and I will be here. If you have any questions concerning where the office is, please see us. I appreciate being here and giving this presentation. I would be glad to answer some questions. (Whereupon there was a question and answer session)

Thank you. (Applause)

President Koff: Thank you very much. That was very informative. For the B&B guys I am sure this is part of a day-to-day walk through their job responsibilities. For us track guys who are in the room, we got another perspective. We deal with the same kind of issues, but not at the same level as the B&B group.

Moving on, we have another excellent speaker here today. His name is Norman Carlson. Norm is international director of transportation managing practices for Arthur Andersen. He is a native of Chicago and a graduate of University of Illinois. Norm joined Arthur Andersen in 1966 and has diverse experience in transportation, manufacturing, leasing, and distribution for industry clients.

Since 1969, Norm has served clients in the railroad industry and the railroad supply industry including manufacturing and leasing. His experience includes consulting and auditing assignments on Class Is, regionals, and shortlines. In addition, he has provided advisory services to railroad acquisitions and initial public stock offerings.

Beyond the railroad industry, he serves clients in trucking and inline barge industries. For the past seven years, Norm has co-sponsored a seminar known as "Railroads for Nonrailroaders" as well as conducting Arthur Andersen's training courses on the railroad industry.

His professional publishing credentials include articles on finance and being quoted in the Wall Street Journal, Railway Age, and several other industry-related trade journals. He has lectured at the University of Illinois Chicago on business and is a member of the Presidents Club at the University of Illinois. He serves on two advisory committees at the University of Illinois here in Chicago.

His civic activities include the Crusade of Mercy and serving as president of a scholarship fund dedicated to assisting students in pursuing careers in public transportation, and serving on the board of directors for Illinois Issues, a public interest magazine in the State of Illinois.

Mr. Carlson is a CPA, a member of Arthur Andersen's observers to a standards setting committee of the American Institute and a member of the Institute's Transportation Committee. He served as a speaker at numerous seminars on corporate financing including financing of railroads.

He has a very interesting talk for us today called "Looking Up From The Track" and I'd ask you to please welcome Norm to our group. (Applause)

LOOKING UP FROM THE TRACK

Norman Carlson

Transportation Director
Arthur Andersen

Good morning. First of all I would like to thank Ken Koff and Reuven Shiloh for the invitation to come and address your conference this morning. I found quite a bit of interest in your theme of maintaining the foundation of today's railroads. I think that is very appropriate because as I have counseled some of my clients without good track and good structures, you are not going to have a very efficient railroad. That will probably underscore some of my remarks today about looking up from the track.

To achieve outstanding productivity and efficiency in the 21st century, sound track and sound structures is going to be necessary. I want to look up from the track today to share a few thoughts with you maybe to cause you to think a little bit about things in a slightly different way and to probably give a few recommendations.

First of all, I would like to review what I am going to talk about and then develop the points. My first suggestion is that the engineering department should develop an even closer tie with the financial and analytical groups within your company. I think that you should increase your awareness of the role of Wall Street and the lenders on how that affects you and what is happening to you and that their role is going to be of greater importance going forward.

I would like to suggest that you look at the role of leadership. It needs to be critically examined. You must ask the questions of yourselves what leadership and structural changes are needed to meet the challenges of the next century.

I think we should ask ourselves what is the true cost of projects. We need to ask the time-honored question is it more efficient for the company as a whole to hold engineering crews or to hold trains.

Finally I recommend to you that universal benchmarking can help you achieve and measure efficiency.

To get an overall perspective of this, I think we only need to look at the impact of the UP/SP merger. The Union Pacific spent $5.4 billion to acquire the SP. Improved service and operating efficiencies will yield $650 million in annual savings and, more importantly, $1.3 billion will be spent to upgrade facilities. Those are big numbers. Those mean a lot of work for a lot of people.

There is an ancient Chinese curse that says, "May you live in interesting times." The most interesting times for the railroad industry are now; not just here in North America, but around the world. In Europe and South America it's privatization which is bringing massive reductions

in employment. In Japan, it's a virtual new order because the railway deficits were literally bankrupting the country of Japan. In China, it is capitalism. Initial public offerings of stock are being made to raise money. Most of that money is coming from the United States just as the Canadian National raised money through an initial public offering to achieve its privatization in Canada.

Not to be left out, we have companies like RailTex and Genesee and Wyoming that are also raising money for different purposes. We now have international railroads. Wisconsin Central is in the United States, Canada, New Zealand, and Great Britain. RailTex is in the United States, Canada, Mexico, Brazil and Russia. A year ago at this time Ed Burkhard got up in front of the shortline meeting and said as he looked at the industry, the Class Is are consolidating at the top and unraveling at the bottom. That comment brought the house down from that group, but if you look at what is happening within the Class Is, they are consolidating. They are also spinning off, and they are making acquisitions. It is quite a variety of activities that they are undertaking. If you look at the Class IIs and Class IIIs, they are also acquiring; they are also consolidating.

Ten years ago would you believe today that there would only be five mega Class I carriers? It is certainly a different world.

That leaves me to one of my initial thoughts. The engineering department should develop an even closer tie with the financial and analytical groups of your company. In my opinion a better mutual understanding of each other's goals and objectives will be a strategic advantage to the company. Why? In the July issue of Railway Age Dave Kelly of the IC is quoted as saying, "Sixty percent of the total assets of a railway is in the rail." By the time you add ties, ballast, OTM, bridges, and structures, you will find that the engineering department is responsible for approximately two-thirds of the value of the railroad. This gives the engineering department the opportunity to have significant impact on the financial performance of the company.

Having set the stage, let's look at the history of your industry. It began almost 107 years ago with the incorporation of the Baltimore and Ohio. One of the incorporators of the B&O was George Brown. Today we have one of the premier investment banking firms on Wall Street still heavily involved in transportation by that name. Over this 170 years we have seen a constant stream of construction, acquisition, consolidation, and, of course, failures and abandonments. Nothing has really changed in 170 years.

If we look at the regional and shortline railroads, some people are saying they are consolidating and this is something new. Examples in the regional and shortlines are Wisconsin Central taking over Green Bay and Western, Fox River Valley and Algoma Central.

In 1996 alone we have seen RailTex acquire the Indiana, Ohio and the Detroit, Toledo and Ironton; Genesee and Wyoming has acquired the Chicago and Illinois Midland; and Pittsburgh and Shawmut. But if you look back in history, what is new about that? There is a little twist out there that may be a little bit new and that is Class I buying pieces of other Class I railroads. Examples? Norfolk Southern buying the old Pennsylvania Main between Hobart and Fort Wayne, Indiana, and more recently the old Peoria and Eastern and New York Central property between Bloomington and Champaign. Somewhere in this realm is CSX's acquisitions of the Paducah and Louisville and the Indiana Railroad which were pieces of the old Illinois Central.

None of this, though, would be able to be accomplished without the complete support of the financial community. This is another one of my messages. I think that it is important for you to understand the role of the financial community and the demands that they place on your company and particularly your financial officers. These demands will become even more critical in the days to come as the need for money grows to support your projects. This is why I suggest to you that it would be in your interest to get to know your financial and analytical people better.

Everybody says it's fun to sit back and look at what is going to happen. I think the transcontinental railroads in the United States and Canada are going to come. I think that we

will have some super regionals. There will be a few large shortline companies. Unfortunately, though, I think like the family farm, the mom and pop shortline is going to be a thing more of memory than reality. But probably the trend that we will see more than any other trend is the enhanced development of international railroads. They will flourish. You may find your company operating in another part of the world. Why? It is because of the skills and the money that is available in the United States to support that kind of activity. There is probably more skill base in this room than there are in some countries of the world.

We look to have full employment going forward. Why will this happen? Because as Wall Street continues to have money and banks continue to have money they are looking for places to put this money. The economies of scale are needed and that's why the consolidations will continue. This is not a business that you can run on a small basis. Mergers and acquisitions will continue because they have the significant savings that occur. We talked about $650 million of savings alone in the UP/SP. These savings in many cases come from the back room and overhead type operations.

This leads me to the next point. Despite all of the things that you have done in the past, and despite all of the efficiencies that you have achieved, more will be asked of you in the future. The demand for efficiency and the demand for savings will continue to come because of the demands of the marketplace and the financial marketplace and the abilities to produce profits.

Why is this focus going to be coming on you more than others? Train and engine crews have been restructured. Consolidations and technologies have been eliminating clerks and back rooms are disappearing. Locomotive technology is reducing the number of units and maintenance is being outsourced to the manufacturers. They are finding that maintaining these things was something completely different from what they thought so they are changing the locomotives a little bit.

We get back to the point made earlier that engineering is responsible for two-thirds of the value of the company. That is going to get you a lot of attention. So what is your role? While I think that the focus on technical matters is extremely important, as we move into the 21st century I think some of that focus is going to shift to what we call the softer elements that are out there. May I ask that you sit back and view what is the true role of civil engineering and construction management and ask yourself does this need more internal and external recognition; internal within my company and external beyond my company. While there is a certain historical romance that surrounds a locomotive engineer and sometimes the crew, where would the railroad be without you? When you ask the question about a railroad engineer, do they think of you or do they think of the guy in the cab of the locomotive? Yet think of your role of looking at two-thirds of the property.

One of the things that I talk about at length with bankers is the multi-faceted complex nature of a railroad. A railroad is a multiplicity of businesses. Transportation is a service business. Maintenance of equipment is a manufacturing business. Interline accounting is a banking business and your business is really a professional engineering firm and a construction firm. The role of leadership needs to be critically examined. Do the demand and control structures that the generals from the civil role brought to the railroad industry work in the information age? The answer is probably obvious, but have your structures changed? You now have more highly skilled people. Are you getting the most from them? Can they function better in tomorrow's environment if motivated and led differently?

In the future, the role of the unskilled person will diminish. He will be a victim of technology both productive technology and information technology and there is the increased need of efficiency of people. Layers of management and supervision will be removed. The line employee must become self motivated and self educated to survive in the 21st century. The question is will your leadership structures and your organizational structures meet the challenges of the next century?

To do more with less requires analysis and measurement. What are the performance measures by which you can document that you have become more efficient? Thus my recommendation that you get closer to your financial and analytical people. The bottom line is going to be productivity measured in terms of dollars as well as productivity measured in terms of units of measure. Specifically, what are your actual costs going to be is going to become of increasing importance. What is the cost of a project? A couple years ago we did some benchmarking for a Class I railroad. While some roads reported relatively high percentage of shift time and actual work, we were surprised to see how much time was not spent working on the project. In some cases, despite the data when you dug under it the reality was that there was probably only three or four hours of work being done on a shift. The rest involved moving equipment back and forth to clear trains and barges as we heard earlier and stopping for passing traffic. Disparate rates and other factors were taking their toll. The question to ask is what would it take to get 8, 10, or 12 hours of continuous work once you get on site? What other construction activities have as much interruption as railroad construction? What is the cost of this inefficiency?

Perhaps some financial analysis is interesting here. One idea could be to compute the cost of your labor, your support people, your equipment, and all of the costs that it takes to have your unit in the field and determine an hourly rate. Compare that to the cost of holding a train for the same hour. Obviously, customer service requirements must be reflected, but where is the biggest bang for the buck for the company as a whole? What is the strategic implications of your only spending part of your time out in the field actually working on your project?

Perception from the outside, at least, the Union Pacific's work on the Powder River Basin this year was a very interesting solution. In talking to some engineers they have really blasted the concept of shutting down the railroad. Others really liked it. But the point of it is it was a creative solution to the problem and there probably needs to be more creative solutions. I'm not necessarily endorsing what the Union Pacific did, but what are some of the creative solutions that you can bring to get more efficiency out of your production.

You may find that the financial people are going to be a champion of your cause because they are looking for further efficiencies of the dollars that are invested. We talked about Wall Street and lenders. Why are they so interested in the railroad industry? They can feel it. They can touch it. They can see it. They can understand it. It's not like something in a black box.

If you look at measures, two of the measures of most success in the financial community are that the stock price of railroads has exceeded the growth in the market and the demand for public offerings is great. On a recent offering for a railroad the request from the streets to buy the stocks was seven times what was offered. There is a lot of money available out there, but it has to be used efficiently. If you look at the cash flow of a railroad, it is like any other business and, in some respects, it is like any personal situation. In a business cash comes from three sources: operation, borrowing from lenders, and sale of equity. Cash is used for four basic things: the purchase of goods and services, the repayment of debt, principle and interest, repayment to the equity holders otherwise known as a dividend, and capital expenditures. It is the capital expenditures that is your world.

Lenders have a thing called financial covenants and sometimes they influence the way that the money is spent. Sometimes the expectation of Wall Street to get more earnings out of the company also increases the way that they are spent. But one of the things that is out there today is that the banks are concerned about the amount of debt that is out there for acquisitions and they want to be repaid first. Those banks have a nasty habit; they want to be repaid. So these are potential impacts on your budget that you will probably have to have greater understanding of in the years ahead. It perhaps explains to you why you are getting the pressures you are getting through your chain of command.

Improved financial performance increases the confidence that lenders and investors have in a company. It also lowers the cost of capital which results in more money being available to

the company. So it is something that runs around in a circle. By increasing your efficiency, you improve the overall results of the company and you contribute greatly more than you imagine to the success of your company.

How do you know when you are being more efficient? Financial performance is going to be extremely important in the years to come. Units of measurement are going to become even more important particularly improvement in the units of measurement. We believe that benchmarking is an area that should be considered. Benchmarking is something that the railroad industry has been doing for a long, long time, but the majority of benchmarking has been against other railroads.

At Arthur Andersen we believe strongly in what is known as universal benchmarking. When you benchmark within your company, that is, within the company itself, that is known as internal benchmarking. When you benchmark within your industry that is known as competitive benchmarking. When you benchmark beyond your industry that is known as universal benchmarking. At Arthur Andersen we believe that universal benchmarking is the way to achieve breakthroughs in performance.

What are some of the more fun examples of universal benchmarking? Southwest Airlines compared their fueling and servicing equipment when they were turning airplanes at airports against Indianapolis pit crews in the 500 race. A gravel company compared its dispatching and weighing of trucks against the technology at ATM machines. They actually gave the guy an ATM card to dispatch his truck and go through the weighing process. The key in this benchmarking is the methods and the processes. The question is what is the function; not what is the industry.

Looking back at earlier portions of my remarks, to me areas that you should consider benchmarking are professional engineering firms to achieve efficiency of your staff, and construction companies to achieve efficiency of your processes. What are your processes? You can go beyond these industries as well because the question is what is the process. The challenge is to reach beyond the obvious and to use your own creativity to find a comparative situation; i.e. Southwest Airlines looking at Indianapolis pit crews in terms of thinking about turning airplanes.

Another strong belief we have at Arthur Andersen is that you can only improve on what you can measure. Considerable thought should be determined in putting into what are the key measurements that you are going to have in your processes. Financial importance will be the ultimate measure of the future.

We have covered a lot of territory, but a lot of the recommendations on what I should cover came from members of your group that I talked to and said, "What do you think would be interesting to the group from a financial perspective?"

In summary, I think the recommendations and research that we did to make this talk today is that the engineering department should develop even closer ties with the financial and analytical groups within your company. I think each of you need a better understanding of the pressures on the other sides. Each of you have a common objective for the strategic advantage of your company. I think that hopefully the awareness of the role of Wall Street and the financial community is having on your company and this will be of increasing importance to you will be understood going into the future. I believe that the role of leadership needs to be critically examined. What leadership and structural changes are needed to meet the challenges of the next century? You will probably have a different skill level in the labor force. You will probably have much more technology than you have today. I think that none of us understands what information technology is going to do to us.

What is the true cost of your project? Should we look at difference ways of examining the time-honored question of is it cheaper or more efficient to hold engineering crews or to hold trains?

Finally, our belief is that universal benchmarking can be a great aid to you in achieving this. What is the bottom line of all of this? Like any other business, including my business, more will be expected to be accomplished with less in the years to come. (Applause)

(Whereupon there was a question and answer session)

President Bradley: Very good. Thank you so much for being with us today. We appreciate it. (Applause)

President Koff: At ths time, weíll adjourn for lunch. Roadmasters will reconvene back here at 1:00 p.m. B&B will meet down the hall in the Cotillion room at 1:30 p.m.

(Adjourn)

BRIDGE AND BUILDING SESSION

Monday, September 23, 1996

President's Address

M.L. Bradley

Conrail

Good afternoon and welcome to the opening session of the 101st B&B Conference. For the registration figures at this time, we have the Roadmasters and the B&B combined; they are not separated. There are 262 B&B and Roadmasters, 18 guests, 250 suppliers, and 77 spouses for a total of 607 to date.

I want to mention as I did earlier in the other session that at 3:30 p.m. this afternoon there is going to be a presentation on the Red River Bridge which is a bridge on the Kansas City Southern. Dave Franz is going to present that report. The committee report on culvert, boxes, and arch liners will not be presented today.

It is customary at this point to give what they call a President's Address. Just as information, I am going to cut it short for the benefit of myself and you. I really want to get into addressing the AREA, Roadmasters, and B&B combined conference and merger in case there are any questions. I will outline it and then we will go to the three people who are sitting on the ad hoc committee. If there are any questions, you can address them at that time.

It's truly an honor to serve as president of the B&B Association. After seven years on the executive board, I am proud to get the opportunity to address this audience. Since the last conference, the B&B Association has continued to offer seminars on bridge inspection, railroad construction, contract seminars, as well as bridge repair seminars. The bridge repair seminar was given for the first time this past spring. Collectively, there were a total of over 90 attendees in the three seminars. That was up until this past Sunday. This past Sunday we held another one and there were another 14 at the railroad construction seminar.

The interest in the seminars has really continued to grow each year. I would like to personally thank the instructors for taking the time out of their own hectic schedules and careers to be the leaders in the industry and go out and present this information throughout the United States.

For the second consecutive year, the B&B Association will award scholarships. If you recall, last year was the first year that we gave two scholarships. This year, however, at one of the board meetings we approved the possibility of giving four scholarships. We will give two

to junior members and if they came back with the same academic criteria in their senior year, all they need to do is reapply. So if someone received the scholarship in their junior year, then they could move on and get it at the senior level by simply reapplying.

The B&B Association's goal is to encourage education while offering its membership additional value at a minimal cost. I understand our first recipient last year, Todd Wimmer, did graduate with a Bachelor of Science degree in civil engineering. He is working now for the Union Pacific Railroad. So after our first year, I think we have been successful in gaining one recipient at least in the railroad industry.

As for the membership, the B&B Association continues to grow and receive active growth. I strongly believe it's in large part due to these seminars that we have been giving. Since the last conference, we have grown approximately 10 percent in our active members. We sent notices out to all life members. If they weren't interested and didn't reply to any of the questionnaires we sent out, we dropped them from the membership rolls. If you compare apples and apples and hold them into last year, we have been gaining membership the last several years. We feel this is very positive in the fact that the railroads are downsizing, merging, and offering buyouts as well. So we feel we must be doing something right to encourage the growth. We do encourage and continue to support and welcome all new members.

When I joined the Association in 1982, my goal was to gain some knowledge in the bridge field and I did that through receiving the Proceedings. At that time I wasn't a participant of the conference. But needless to say, after all those years, I have been blessed to have the opportunity to attend these conferences and meet most of the distinguished leaders of the bridge and building field and to gain the knowledge from their participation in this conference, not to mention the friendships I have developed over the years.

I would be remiss if I didn't thank some individuals who are responsible for my participation and success in the B&B Association. Jerry Cossel, who is now our retired chief engineer construction, and John Kapp who is now our assistant engineer construction, were both instrumental in my being able to go to both the conferences and any meetings after I was elected to the board. I know without a doubt, if it wasn't for their support, I wouldn't be standing up here now.

There were a few other individuals that encouraged my growth in the association as well. Some of the them I would like to mention now, too. They are Mike McMasters who has left Conrail and is now with CSX as assistant chief engineer, Jim Richter who is our assistant chief engineer structures, and Charlie Yordy who is our director of capital bridge programs. They are very supportive of this Association and they encourage membership in the Association.

The thing that really is on everybody's mind, at least up to this point we are receiving a lot of phone calls, is what we call the news-breaking story in the industry. Shortly after the June meeting in Boston with the AREA, Roadmasters, and B&B, we announced to the RT&S that we were intending to have a joint 1998 conference as well as a possible consolidation merger between all three organizations. What has really driven us are the buyouts and corporate downsizing. Along with comments we have been receiving regarding the support that we are going to get towards just one conference from upper management. We have been in negotiation with the other two associations. I can tell you any time there is change, people resist to a certain point. But inevitably something like this is going to have to happen.

We are in negotiations trying to get the best for our membership. There are going to be considerable discussions on bylaws, constitution, and conference programs. It is already going on. There is an ad hoc committee that consists of nine individuals, three from each association. Our three are Mark Walbrun, our past president, Joe Lileikis, our incoming president, and Dave Franz, our vice president in the Association. We have facilitators for those meetings.

I am eventually going to turn this over to Mark as he has been to every meeting. What I would like to do is have him add anything he feels necessary to what I have to say. If anyone has any questions, I would like to open it up to the floor because we want your opinion. I think

the committee needs to know how you feel and where we are heading with this. I think Mark and Joe and Dave are probably the best three to answer any questions because they have been to the meetings. We are moving forward with this and we want to see what type of proposal we get towards the end.

Mark, if you would come up, please.

Mr. Walbrun: Thank you, Mike. This was truly an interesting year. We started out the year expecting it would be like most of the others in the Bridge and Building Association. We were fine-tuning here and there to make the Association more efficient, give more service to our members, and looking at adding seminars. Then by around June things began to change quite dramatically.

There is generally a feeling in the railroad industry that the amount of time available for people to not only do their jobs but also prove themselves and contribute to the wellbeing of the industry is being squeezed to an extent that has not been seen before. We were challenged to react to that. It was not only the Bridge and Building Association, but the Roadmasters Association and the American Railway Engineering Association.

The intention of our combined board meeting in Boston was simply to discuss how we could best look at the possibility of using a single conference to avoid travel costs and the redundant costs of people that attend both conferences and just sort of get some synergies by using common facilities.

During that meeting, we had a number of discussions with others that were of a similar mind that we can receive an awful lot more if we could look at the possibility of using one organization to operate all three entities. Although there was some resistance initially when we first considered that, we had to admit that after we took a poll and talked to the people involved that really in the long term it made an awful lot of sense. It really was the best thing for the industry at large.

As we began to spend some time looking it over, we found that we could fashion a new organization that could be even better than the services we have had in the past. No one more so than me and the others recognizes the fact that this industry and this association has had over 100 years together and we feel that we made a major contribution in the railroad industry all these years. But on the other hand as Mike said, times are changing. It's a different industry than it was 100 years ago. We have a very small cadre of people that have the knowledge and the experience to run the railroads in the United States. I think it's critical that they get together and exchange information. To do that, they need a viable organization and a viable organization has to look at how best to serve its members.

We have made fairly good strides at getting through all of the initial work in the possibility of a merger. We have looked at the legal aspects. We have looked at the financial aspects as well. We have set a target date. We are looking at the possibility, if our members and our boards approve it, of August 1, 1998. The first conference that would be held as a joint association would be in September of 1998.

One of the key issues, though, in the conference is the way the proposed organization would be structured and that there would be four separate and distinct organizations within the larger organization. Each one of them would run their own conference and their own group. One of them would be a structures organization. There is also a track, a passenger, and an engineering services division. Each one of them would present their own problems, their own concerns, and their own speakers. They would run their own conference, but like the mechanical association, it would be done at the same hotel at the same time allowing members to go from one meeting to the other and pick and choose what they found most interesting out of the group. This expands the amount of information available while still retaining all of the important programs, including the seminars and educational items that we have all appreciated.

It also puts the organizations on a more even financial footing where each organization is helping shoulder the burden of the other ones. We are able to make the best use of limited staff members and times available.

So with that, we have a very strong program today, but I would like to take any questions and concerns anyone might have. Thank you.

President Bradley: Thank you, Mark. I would like to reiterate the fact that what they are discussing at this time, whether it be structure or fees, are merely proposals at this point. It has to go before the board and it has to go out to the members to vote. Eventually the members have to approve it. They are working very diligently toward that.

The other aspect of it is the fact that we have REMSA to think about. They are being squeezed, too, on the dollars and they are very much in favor of trying to reduce their costs as well by having mini shows. A large exhibit is an expense to REMSA. So everybody in the industry is being pressured.

So with that, we will get started on our program. I would like to introduce Dave Franz. He is going to introduce our first presentation. Dave is one of our vice presidents.

Mr. Franz: Our first speaker this afternoon is Dr. Gene Corley with Construction Technology Laboratories right here in Skokie.

Dr. Corley received his Bachelor of Science in civil engineering from the University of Illinois in 1958. He then succeeded in getting his Masters and Ph.D. shortly thereafter also at the University of Illinois.

He started his career with the highway department in Shelby County, Illinois, working on highways, roads, and structures.

After he got his Ph.D., he worked for the Corps of Engineers as research and development coordinator. In 1964, he started working with Portland Cement Association and was involved in the development of design processes and structural concrete, concrete pavement, railroads and structures subjected to fire loads. He also was involved in the investigations of damage and deteriorated structures.

Dr. Corley has published more than 100 technical papers and books. He is presently vice president of Construction Technology Laboratories and has served in that position since 1987. After the presentation, if you care to get more information about Dr. Corley on some of the information he has presented, there are some things available in the back of the room.

At this point, I would like to introduce Dr. Gene Corley. Would you please welcome him. (Applause)

CONCRETE REPAIRS AND EVALUATION

Dr. W. Gene Corley

Vice President
Construction Technology Laboratories, Inc.

Thank you for the introduction. Over the next few minutes, I would like to do three things. I would like to first talk a little bit about blemishes and things that can go wrong with concrete when it is being placed. I would then like to talk about nondestructive testing. The first part will deal with things you can see that are wrong with concrete. The second part will deal with those that you suspect but can't see and how to find out if there really might be something wrong. Then in the last few minutes I would like to go through a little information on repairs of concrete.

Now, there is another session that is being given later that also will talk a little about repairs. In that session they will give you some more detail on the final things I say about picking materials that are appropriate for repairing.

Let's first talk about things that can go wrong with concrete when it is placed. In the placing and finishing of concrete, that's the time when most things can go wrong. Once it is in place, the die has been cast, and there is not too much you can do to keep things from going wrong. You then have to deal with repairing it if there are some things wrong. While there are many things that can go wrong, I will talk about some of the common ones such as how to identify them and then what to do to avoid them going wrong.

Now, there is a brochure put out by Portland Cement Association that describes the defects I will be talking about plus a lot more. It also tells you how to avoid them and, in some cases, how to repair them.

One of the things that can go wrong when you are placing concrete flatwork is that you can get dusting. Dusting is caused by getting too much water on the surface of the concrete so that while the concrete may hydrate, it does not stick together. So you end up with dust instead of a nice, hard surface. Now, one of the ways to avoid this is to choose a concrete mix that will not bleed after it is in place or at least the bleeding is minimized. Also your finishing time needs to be watched and you can minimize this by finishing it at the right time after the bleeding has dissipated.

A second and very common one that you see is scaling due to freeze/thaw damage to the concrete. You have seen it on sidewalks and driveways, but hopefully you haven't seen it on highway pavement because there they do the things that are necessary to minimize the likelihood of scaling. The way you prevent scaling is to provide a quality concrete with a nice low water cement ratio, but very importantly, has adequate air entrainment. So you must ask for the air entrainment and the quality control for placement of the concrete with air entrainment to ensure that it really has gotten in there.

Another placing and finishing problem you run into fairly commonly is blistering. Again, this has to do with the bleeding of the concrete. But in the case of blistering, it also is related to the finishing. It is very important that the concrete be finished at the right time. It should be finished after the bleed water, if any, has gotten out of the concrete. If you have a particularly hot day or other conditions that cause the surface of the concrete to set prematurely, it may appear that the concrete is ready for finishing when, in fact, it is not quite ready yet. It has formed a surface layer and then the bleed water occurs under that surface layer after you have done some initial finishing. You then get a blister which if you take a cross section of the concrete you will be able to see what the blister looks like.

Here I have taken a piece of concrete cut out of a slab with blisters and you can see a blister where the bleed water has accumulated and caused the cracks to form.

Another common thing that will happen, particularly in warm weather if you have wind while you are placing the concrete, is plastic shrinkage cracking. Plastic shrinkage cracking comes from premature drying of the surface. It's a loss of water on the surface of the concrete. Usually it is not a problem that you have to worry about as far as the durability or strength of the structure is concerned. It is usually more a cosmetic problem rather than a serious problem. The plastic shrinkage cracking usually is found to be a millimeter deep or less and doesn't really do much to the life of the structure. But you should avoid it nonetheless. How do you do that? You must keep the surface moist, particularly when there is a wind so that it doesn't dry prematurely.

Contrasted to the plastic shrinkage cracking is drying shrinkage cracking which occurs naturally in all concrete with time. This will not occur while you are actually placing and finishing the concrete but will occur after the concrete set, after it is dried out, and the shrinkage has occurred. Sometimes it will be six months later, a year later, or maybe up to two years later before you get the drying shrinkage. Drying shrinkage cracks and flectural cracks, that is stress

related cracks, are okay as long as they are within some reasonable width. By definition in the ACI document, that width is about 13 thousandths of an inch average for outdoor exposure, and about 16 thousandths of an inch average for other exposures that aren't severe exposures.

How big is that? Well, let me show you something. We have some crack comparators in the back that you can pick up and you can look on the inside. What you do with this is compare the width of the line with the crack. If you look over on the inch side you will see the 16 thousandths and the 13 thousandths of an inch mark. Those cracks are normal cracks that are to be expected from drying shrinkage, flectural cracks and so forth. Due to variability in cracking you can also expect up to 50 percent wider or narrower portions of a crack over its length. So add 50 percent to those. Anything within 25 thousandths, even up to 30 thousandths is not likely to be a crack that indicates there is something seriously wrong with the concrete.

One caution is you should measure deep down in the crack where it has not weathered away. After a while cracks will weather away and they will be much wider than that. You measure over the width where it initially cracked.

Another common defect in some parts of the country is reacting aggregate. In the Midwest we have many natural aggregates that have chirt in them. The chirt will react with the alkali in Portland Cement and will expand and cause pop outs. Usually they are just ugly and don't cause any strength problems. They may end up being a bit of a durability problem after a while, but usually it's just an appearance problem. If you have too much of it, though, you can get enough reactivity and it can become a strength problem.

Another defect that occurs in the placement of concrete is honeycombing. This is probably the most common defect that you can run into. Actually I show the honeycombing and of course the crack in whatever the structure was defines the weak spot as the honeycombing. So the crack runs right through the honeycomb. Honeycombing is something that should be repaired immediately after the forms are stripped. If you follow the procedures of ACI 301 they tell you how to patch defects like this. If they are patched immediately upon stripping you will get a sound patch that will stay there as long as the rest of the structure.

Another thing that you see on concrete that is considered to be a blemish rather than a defect, is bug holes. Bug holes occur when bubbles of air or water are trapped on the vertical surfaces of the forms. When the forms are pulled you are left with those small holes. In architectural concrete in some cases it is desirable to get rid of all of the bug holes, but in normal concrete where it is not architectural concrete, they should be left alone. There is really no need to do anything to them. In fact, in some cases it enhances the appearance of the structure. It's a part of the rough looking surface that was intended for the structure.

The final placing and finishing blemish I would like to mention to you is the freezing of plastic concrete. This can occur when cold weather concreting practices are not followed. You start placing the concrete not when the temperature is 34 and rising but when it's ready to fall. If the concrete is not protected you can get damage due to the crystals that form in the plastic concrete.

Now, all of these blemishes and defects can be repaired. We will talk a little bit about the repairs in the third section. I would like to now go on beneath the surface of the concrete and talk about a few of the methods that are available for you to find out what is underneath the concrete without chipping in and looking.

Obviously if you think there is something wrong and you have to chip in to find out, then it doesn't matter whether it was or wasn't wrong, you destroyed the concrete anyhow. So what we want to do is be able to look beneath the surface and see what is there.

The first method is the R meter or tachometer and that is a way of finding rebar in concrete. Sounding is probably the one that I use the most. What that really means is you take a hammer or a chisel or a coin or anything that will ring when you tap it on concrete. You tap the concrete and you can hear if it's delaminating. It's the most common type of nondestructive testing that there is.

Mr. Lileikis: Thank you. Our next presentation is General Principles of Control Systems. The presenter is Tom Collier with Ercon Development Company. Tom.

GENERAL PRINCIPLES OF CONTROL SYSTEMS

Tom Collier

Ercon Development Company

This is one of the first installations using these net type panels. It was done in 1981.

This is the same installation a couple of years later. You can see that the bank is secreted. There is vegetation also. This thing is no longer an active eroding bank.

This is a bridge where the same technique was used as we saw in the drawing to realign the channel of the bridge. You can see the abutments getting eaten away pretty badly.

This is another picture of it. You can see how the channel is now moved around to the outside of these.

This is a picture showing how the sand builds up in these nets. You can slow the water down a little and if you get a stream with a large sediment load, it will drop it pretty quickly.

This is another example and shows you a couple of things. First, you can see the amount of sand built up in these things. These are 8 or 12 foot high panels and they are just about gone. You can also see where the debris is. What is happening to our laminar flow is you get quite a bit of turbulence and you get these big pockets scoured in there.

The main point is it still works. These things will withstand quite a bit of debris. The worst problem that you have from a debris standpoint such as in some spots in California where you have a lot of grass coming down is you get thatching in it and you load the whole thing up. You make it basically an impermeable structure and the pile won't stand it.

This shows another situation. In a lot of places, such as the Cimarron River in Oklahoma, a great deal of the bed goes into suspension during a flow event. These things are designed so they slide down on these pilings. That way when the bed goes into suspension they can maintain contact with the bottom so they continue to function.

This is another situation where we walled behind it. It was going over the riprap wall and we used it to reinforce the toe.

Here is another situation where there's a tremendous amount of debris. However, at this point in time these structures aren't under a lot of load. There is so much sediment in there that the only purpose they are serving is to hold sand in place. Unlike riprap or a lot of bank armoring systems where they are constantly under load, as this process secretion occurs and these things become buried the stress is taken off of them so they will last a long time.

This is a situation on the Red River that was installed there several years ago. You can see it was very active eroding bank. I want to call your attention to the little bar. Then see that same bar a few months later. You can see the water diverted somewhat away from there. This is practically closed off and the sand is building up in the system.

This is the same location about a year or year and a half later. Now all of this is closed off and the flow is in this area and there is quite a bit of sediment in the system.

This is about three or four years later. This is where the system is. This river was very low at this point but you can see this has mostly moved over to the other side now. There is no flow through that area at all.

This is something we did for Santa Fe in Colorado on the Arkansas River some years ago. Actually this bank was getting into the right-of-way. This channel was actually over in one area and we moved it back, backfilled, and armored the wall using these permeable structures to stop the migration of this bank.

Here is another situation showing it's practically buried.

I believe this picture was taken on the Rio Puerco out in western New Mexico or eastern Arizona.

This is another location on the Arkansas River that we did. This time the flow is coming the other way. You can see they didn't have a lot left to work with right there.

The main point I want to make is that with most of these erosion problems, by the time you see results it's a little bit too late. You really need to look back up your right-of-way. You need to pay attention to what is coming at you. Just like those locomotives that can slip up on you on the track you need to watch the rivers, too.

You have to get beyond the property and look up the river and see what is coming. A lot of these problems can be solved pretty economically if they are caught early enough. When they are not, it's expensive. Then a lot of times they are very difficult to solve so that they don't come back to haunt you later.

Thank you very much. (Applause)

Mr. Franz: Thank you, Tom. I think everyone will agree that was a very interesting presentation.

The next topic today is going to be bridge tie installation techniques. Our presenter, John Payton, comes from a railroad family. His father worked over 30 years with the Chicago and Northwestern.

John has 20 years of experience as a track laborer, surveyor, structural engineer, mechanical engineer, bridge design engineer, and consultant.

About eight years ago, he left Union Pacific Railroad to open a railroad consulting firm in Omaha called EcoTech. In July of this year, EcoTech merged with Westwood Professional Services in Eden Prairie, Minnesota, where he is now a senior associate.

He holds a Bachelor of Science degree in civil engineering from Iowa State University and a MBA from the University of Nebraska. Let's hope their MBAs are better than their football team. (Laughter)

He is a licensed professional engineer and a member of various associations and professional groups. Please welcome John Payton.

COMMITTEE REPORT

BRIDGE TIE INSTALLATION TECHNIQUES

Chairman: John Payton, President, EcoTech, Inc.

Thank you, and good afternoon, President Bradley, Association members and guests. As you have gathered from my introduction, in the last few weeks my former consulting company EcoTech out of Omaha has merged with another consulting firm, Westwood, in Eden Prairie, Minnesota.

Having worked in Omaha for nearly 15 years and lived in the same home for the same duration, I now have a soft spot for those that have gone through mergers and relocations. Mercy, what a stresser.

On one of the many trips to Eden Prairie, I had the opportunity to take my 12 year old son, Josh, along. Heading back to Omaha, we were a little behind schedule and needing to get a bite to eat. We swung into a wooden floor and stove pipe cafe called Emma Krumbee's.

I told the waitress we were in a hurry and without even picking up the menu asked her for the quickest house specialty. She replied, "Why, our hot roast beefs are the best."

I said, "Sounds great, bring us a couple."

Within a matter of a couple of minutes, out from the kitchen came the waitress with a large platter in each hand with a comet trail of steam trailing behind.

She landed those platters on the table as skillfully as a navy flyer landing his jet in rough seas.

There on the table before Josh and I where two platters loaded with two of the biggest slices of Texas bread I have ever seen, an inch of roast beef, and a couple pounds of mashed potatoes covered with over a pint of brown gravy.

Josh being a cheese burger and fries type of kid looked up at me with one of those "deer in the head-light looks." He just didn't have a clue on how to even begin to eat such a thing. He just sat there and waited to see dad's first move.

Being an engineer type not afraid to tackle any problem given the opportunity to break it down into smaller tasks, I picked up my knife and fork. I whittled off a corner, taking small equal amounts of bread, beef, potatoes, and gravy. Josh seeing this, puts on a big grin and an approving nod, mimics dad. After taking his first bite, he nods again smiles and says, "Kind - a - tasty - dad."

I then proceeded to work on my meal. I cut off another round of equally balanced bread, beef, potatoes, and brown gravy.

Glancing up at the boy, as I was placing my second mouthful, Josh had already taken his knife and fork, slashed away at the mounds of white potatoes, bread and beef and stirred up the gravy into a blended brown mess. He had a fork in one hand, spoon in the other. I was thinking at the time; I should feed this kid more regularly.

Within a couple of minutes that kid had devoured everything.

Josh saw what needed to be done. He picked up his utensils and quickly arrived at a solution. With as little effort as possible, even at the risk of making a mess of things, he became a highly efficient eating machine.

Having been around railroading as a kid, an employee, and now as consultant, I have seen a lot of messes. We have all seen a lot of messes. Some are due to equipment failures, some are due to communication failures, some are due to human error, and some are due to the differences in opinion on how to get the job done.

As a highway and railway consultant, I have seen many different methodologies on how to get the job done quickly and within budget. When I have bid roadway jobs, I know that all the contractors utilize practically all the same equipment and generally buy their materials from the same supply houses. But when it comes time to put a man-hour cost to the project each contractor has a little different slant on how long it will take to do the job. Historically when projects are bid, and this is important, I will let you forget everything else I have said, but just remember this simple fact:

"The one that picks it up once and places it once - wins."

"The one that picks it up once and places it once - wins."

Think about it. It does not matter if its paperwork or dirt work. Each time you pick up the pencil or that pile of dirt, tie, rail clip, or bar a second or third time, you have created a delay or additional time charges in getting the job done.

When it comes to the dollars and sense of project management most of you are cognizant of this "pick-it-once principle". Many of you perhaps do not have the luxury of fully mastering this principle.

Possibly the number of hurry up projects have caused a ping pong effect between all projects and ultimately some projects get a little messy and over budget. You and your crews are continuously picking up projects where they were left off, and each time it costs a little more.

I get a kick out of seeing roadway or track equipment and crews being used innovatively on projects.

Contractors and railroaders alike have experimented and tested literally thousands of ways to efficiently improve upon perhaps one function or task that seems to be a bottleneck in getting a project completed.

To smoothly, safely, efficiently complete the project, is it not the goal?

Charles Russell, of the Norfolk Southern, is an innovator in the pick it once and place it once principle. Now I don't like stealing the limelight away from anyone, but if Charles would have come forward at this time he could have finished the presentation.

Charles and the Norfolk Southern have designed and built two new innovative pieces of bridge tie installation equipment. A few years ago, Charles contacted a number of different railway equipment manufacturers to build the equipment for him, but was unsuccessful. However, he was able, with much discussion and the support of upper management, to invest the needed time and materials into the construction of the prototypes.

Now you, the members of this audience, will be some of the first to see the equipment on video today.

By the way, Charles will make plan sets available at a very offensive price. (just kidding) (Laughter)

The new equipment has the acronyms of D-A-M-I-T 1 and D-A-M-I-T 2 or Design and Modify in Transit 1 and 2.

Let's roll the video - turn down the volumes. You may substitute your own machinery and air impact wrench noises.

(Whereupon there was a video presentation with the accompanying remarks)

Here you see everything is loaded up, ready for a new day and ready to pull out.

Damit 1 is the hook bolt machine. The baskets are in the stored and traveling position.

Battery chargers are being disconnected.

Damit 2 is the guard rail machine. It has 32 guard rail timbers loaded on top with tag and lifting lines stored and ready to roll. Everything is picked up and loaded - drive-through spikes, hook bolts, and tie spikes are all loaded.

This first sequence is the tie inserter crane setting down the rail and getting ready for another 13 tie reach. As you can see the guard rail timbers have been removed by this three man sub-crew shown here.

The entire bridge tie installation crew is a 10 man crew. There are three men removing old timbers, setting new ties and plates, a Little Giant operator, three men aligning, setting hook bolts, and spiking rail, and two men replacing the guard timbers.

Here we see the jacks are lowered and the rail is lifted. When the rail is high enough timber blocks are placed under for short-term support so that the equipment does not support the rail during tie replacement.

The rail anchors are spread apart to ease tie removal. The spikes are removed from every ten ties and a double jawed gauge rod is left in between those ten ties so that the tie crane has better track stability. Every fifth tie either is spiked or has a double jawed gauge rod.

Now you can see the wood block in place.

The men are now loading the tie plates onto a small cart Charles made with a small conveyor belt. This little piece of equipment helps to get the tie plates and pads out of the way with little effort. Pick it up once. They will reverse the process to place the tie plates and pads on the new ties. Putting it down once.

There are 26 tie plates on the cart.

Now the tie inserter operator begins to shift and set the ties over the side to get the ties out of the dap. The rail anchors left on and some clip bolts may cause problems in getting the ties out, so the men standing will use pointed lining bars to assist in the tie removal. The tie inserter operator will get four, five, or six ties set up this way and then grab the ends for final pulling.

They were able on this project to drop the ties on the ground and a tie salvage company picked them up the ties later.

You can see the brooms that are used to clear debris from the top of the flanges. The men have stored the brooms and grabbed point bars to aid the tie crane operator in inserting and aligning the new bridge ties.

As the ties are placed, the rail anchors are knocked back into proper position.

Now the tie plates and pads are being installed. The conveyor helps to eliminate steps and reaching so far. The bridge ties are brought to the tie crane by a Little Giant crane with a clam shell. It is able to pick up and place five ties side by side on the back of the tie crane without any additional assistance.

The hook bolts are installed by a man slung over the side in an air basket. They drive the hook bolts into position and if the pre-drilled holes are too far out from the beam flange he has an air drill to drill a new hole.

He is placing a washer and a lock nut, then tightens the nut with an air impact wrench loaded in the basket.

This operation is done every third tie on the Norfolk Southern.

Here you see an air spiker driving the spikes. They are not being preset.

This is the control panel for the track alignment and gauging on DAMIT 1.

The air brake for travel is the black lever.

They are now over a hook bolt tie and readying to align the rail.

A spring loaded track gage is used with an offset board attached on the left.

The rail has been clamped.

They are aligning for gage first, then track center. After alignment the rail is spiked.

After the rail is in place the guard timbers are laid and held at proper gauge with a forty penny nail.

Now you can see the guard timbers being lifted off of DAMIT 2 and placed into proper position. The lifting straps and tag lines are all on the guard timbers and easy to access by the equipment operator.

One man controls the back and the equipment operator controls the other end.

The tag lines are then removed, lowering the guard timber into position and finally removing the lifting strap.

The operator will then swing the boom to the other side and hook the lifting strap for the guard timber on the opposite side.

This man is getting his timber block gauge and driving a 40 penny nail for position. They will then field drill the holes for the timber drive spikes with air drills. Each man working on a side as they go. Staggering the holes is to lessen the likelihood of future splitting of the timber along one plane.

Here we have returned to the gauging and alignment operation for a different look. The ties are being spiked to the last gauging and hook bolt location and ready to move on to the next third tie.

Once the rail has been gauged the operator calls to the Little Giant operator doubling as a transit operator for a shot at the offset board and assist in moving the rail in or out.

The aligned rail is then spiked.

The equipment operator is fall protected by a retractable lanyard. After a few hours of twisting around, the operator got tangled up a bit in his lanyard and needed to straighten it out.

There is a good look at the offset timber on the spring loaded gauge. Now they are spiking up the intermediate ties and getting ready to move up.

After the holes were drilled in the guard timbers the drive spikes are driven with air spike hammer presses mounted on cantilevered arms which are mounted on rails on each side of the equipment. Here is a second view of the hook bolter air baskets. Hydraulic cylinders are used to swing the spider arms and move the baskets into vertical and horizontal position. The operator swings himself into position to install another hook bolt.

More spiking operations. A view of the tag and lifting straps.

Levers on the air spikers and a view of the cam followers used to make the cantilevered assembly.

A wind speed indicator is also one of the machines.

If the wind is blowing more than 10 mph, men and equipment are removed from the bridge for safety.

And here is one last look of the equipment all loaded up and ready to go out again. Once again, this is a 10-man crew.

In April of this year, in seventeen days this crew replaced 2,044 ties. Two of the seventeen days were bad weather days and no work. The crew averaged, on days worked, 157 ties per day with a six-hour track time window each day

That is a production rate of nearly 2 1/2 ties per man per track hour. I think Charles Russell and the Norfolk Southern deserve a round of applause.

Any questions?

In closing, remember Josh and that pile of spuds, beef, and gravy. He picked up his knife once – he won.

Thank you.

President Bradley: Thank you, John. I am sure we all found that to be a very interesting presentation.

This is program change number one for the 1996 conference. We were to have Doug DeBerg give us a presentation on culverts. Doug, unfortunately, was unable to make this conference and consequently that presentation will not be offered.

However, Dave Franz of the Kansas City Southern is going to give us a presentation on a navigation project where they constructed a new bridge on the Red River in Alexandria, Louisiana, and had about a seven mile track realignment in the process. Dave is vice president of the Association and is a 1976 graduate of the University of Cincinnati. After that, he spent about ten years with the now defunct Milwaukee Road and went from there to work for about three years with Envirodyne Engineers here in Chicago. After that, he got back in the railroad industry with the Kansas City Southern where he has been a bridge engineer for about the last eight years.

Dave and I have worked very closely together many times in the past. We have gone to battle with many people and many governmental agencies especially the people down in Louisiana. We have really enjoyed those types of environments and that combat. So with that, please welcome Dave Franz. (Applause)

Red River Bridge on KCS

Dave Franz

Bridge Engineer
Kansas City Southern

In about 1976, the Coast Guard and Corps of Engineers first approached KCS about modifying our existing swingspan over the Red River in Alexandria, Louisiana. There were a lot of negotiations that took place for quite a few years. Initially, they were looking at just modifying the swingspan. We ended up combining several functions, one of which was the I-49 project which was also in Alexandria. We ended up relocating our bridge in a small yard outside

of the city. This was constructed with federal and also KCS funding. That is what I am going to talk about today.

We actually signed a contract in 1985 to do this project. Of course, government being what it is, we got started about 1992.

This shows the KCS system. I have marked where the project is. Our highest density main line runs from Kansas City down to Shreveport and then we have a line that runs to New Orleans along with a lot of other lines, too. But if you look at the line from Shreveport to New Orleans, you can see Alexandria. We cross the Red River at that location.

This is a map of the project. The main line used to come down here where we crossed the river. The brighter yellow is the old alignment. We went right through downtown Alexandria. We had an old yard and you can see I-49 coming through. We were kind of interfering with what they wanted to do for that. So the funding package that was put together for our new structure included substantial savings at the I-49 project by getting us out of town.

We ended up building a new smaller yard. For the new alignment, we stayed north of the river, crossed over, went through a Kraft paper plant and crossed the river. There were quite a few hydraulic studies done to decide where would be the best place to locate the bridge with regards to navigation and possible silting. They were doing locks and dams up and down the Red River to make it navigable. There were a lot of studies done to pick this location.

Some of the features that we will be looking at obviously involve the bridge over the Red River. We had some auxiliary bridges as well, but Highway 1 goes through here as well so we had to bridge over that. There is a levy just south of the Red River which we had to cross over. Then over on the other side, there was a 36 inch water line that runs at a real high skew angle to our proposed main line which supplied Kraft paper plant. They had no backup system; therefore, when we worked around that we had to be very careful. I think their liquidated damages were about $176,000 dollars a day so we treated that with a little bit of care. We ended up putting a 150 foot span over it and driving all sorts of piling in to protect it. It was worth quite a bit of effort.

This is our old bridge across the river. This is right downtown. You can see a highway bridge right adjacent to it. It's a typical old railroad swingspan pier connected trusses. A few of the piers were on pilings and several of them were old timber caissons. The bridge also had a fairly long approach on the north end. We had a few through plate girders over some local roads in town as well as some pile trestles. It's a beauty.

We decided as an organization, in conjunction with our consultants, to be the general contractors on this project and let several different contracts. We broke it out into several areas for a couple reasons. One, we thought we could get the best price that way. The other reason was we thought we could get the best quality by selecting each contractor in the area in which they specialize rather than, in general, go out and see how cheap you can buy things.

We had a substructure and an approach bridge which is basically all the contract substructure units. Then in a lot of our approach structures you will see prestressed concrete spans. That was all included in that substructure or concrete contract.

We had steel superstructure for the deck plate girder span and truss spans. We had two dirt work contractors; one on the south side of the river, and one on the north side of the river. We hired a separate track work contractor and finally we hired a separate demolition contractor. I think it was a little more work for us, but in the long run I believe it really paid off in terms of both costs and the quality of the work we got done.

Of course, initially we were driving quite a few piling out here so we had driven some test piles and performed load tests on them to make sure our depth was adequate and get our lengths for ordering our production piling.

The substructure contractor which is the first one we let was Austin Bridge and Road out of Texas. They built a small dock facility. They had driven some piling and put in some bulkheads where they could pull up to. They brought in a lot of their material by water. They unloaded the H-piles for the piers.

Here you can see on the south approach, which was the longer of the two bridge approaches, the foundation is now in place. I didn't have any pictures of the piling being driven. When we bid the job we actually put in an alternate. We showed prestressed concrete piling with an alternate of H-piles. As it turned out, the H-pile alternate was quite a bit cheaper. The contractor felt it would be a lot easier to work with and that's what we ended up going with. The apparent low bidder with the base bid turned out not being low bidder when we found the H-pile alternates and he was a little less than happy. He told us H-piles wouldn't work here.

Here you can see the footing caps, the base of the piers, and you can see the reinforcing now. To save on concrete, we went with column shafts once we got out of the ground.

Here you can see the piers as they come up with the columns. A lot of these are getting ready for the caps to go on now. You can see how far it extends down. We haven't let the dirt work contractor down there. We were just getting ready to, but I think you can see way down at the far end that is the end of the bridge. We will be going with fill material from then on out. There was an early plan considered to take fill material right up to the end of the river which would have been with 50 or 60 foot high fill. In Louisiana, that would have been something to behold. You would need about five or six to one slopes and the geotech said we should only have one or two feet of settlement over the first few years. (Laughter) We shortened our fill up.

Here you can see on the south approach, again, all the pier work is basically done. These approach spans are AASHTO type four beams. These are about 70 foot spans and we have five of them in there. We have used these quite a bit on the KCS with great success especially in Louisiana and Texas. Everybody and his brother makes these things and you can really get them at a good price.

This is another view from the other end of the bridge. The abutment isn't built yet. They have to coordinate that work with the dirt work contractor, but you can see looking back towards the river some of these bigger openings would be Highway 1. There is a levy down there. It's a little dark and those cranes are over towards the river. This is another view from up in the crane bucket. We are looking back. We are right at the edge of the river and we are looking back to the south. The alignment curves over our existing main line and is back in the trees.

This is the north approach. This got pretty tall in a hurry. We are standing pretty close to the north abutment looking south towards the river from the north approach.

You can see we have already got all the piers in and they are putting up the AASHTO beams. You can see them lifting a beam up into place.

This is basically the north approach with all the beams in place. You can see one space down there. There is a hole where one of the steel spans will go. I believe that's where the water line crossed underneath us. That will get a 125 foot deck plate girder across it.

This is from the river's edge looking back towards the north approach. You can see we are getting pretty high up in the air. I believe we were 52 feet above the 2 percent flow line for navigation clearances over the Red River.

Now I will show you some of the river work. This was an interesting project for me. I had never been involved with dredged caisson work before. This was a first for me. We had two of them on this project.

This is for the protection cells. The contractor decided, and it was a pretty smart idea, to put his protection cells in first to protect his caissons while they were going down. This cluster of piles will be a guide when he starts dropping his caisson which will be down off to the side. But he has driven in a template for his sheet pile cell.

This picture shows he has driven all the piling and he is filling it with riprap.

This is looking across the river at the other side. You can see the other cell. They obviously haven't filled that one yet. There are the guide piles I was talking about where we will eventually put the caissons.

This shows one of the cutting edges for the caissons. These are steel edged. There is also another steel wall on the inside so these float. It actually was fabricated in Tennessee and floated from the Tennessee River to the Mississippi and then back up to the Red River to this location. We had to have certain water depths when they did this and there was some delay in the project getting it floated into location.

This caisson is starting to get into position where they can sink it. It's still just floating. You can see the size of these cutting edges. The actual size of the caisson was about 38 feet wide by 65 feet long. You will see in subsequent photographs the dredge wells were about 24 feet in diameter.

Obviously when you are sinking a caisson like this you want to get a good square start and take it straight down. Austin Bridge retained a guy who had done quite a bit of caisson work and they picked this gradation of rock. They made a bed all around the area where the cutting edge would set so they could get uniform elevation. They needed to get it nicely plumb and straight before they start taking it down. This also precludes scouring early on in the sinking process. It would let it shift to one side or the other.

Here again are the guide pilings they will use to keep it going.

Now you can see they have started to sink the caisson. There is another steel wall inside the steel wall. It doesn't come full depth, but it does come up part way. Of course as they fill that with concrete it goes down and sits on the bottom. Then they start dredging it and taking it on down. They keep making subsequent concrete pours.

Here you can see it again tied up to those guides. There are also jets premounted on the inside of the cutting edge to help level the caisson as it went down with the jet material in certain locations.

Here they are making a concrete pour. They have made a couple of pours in the bottom of the caisson. There were steel walls that went around the dredge wells. That made this hole assembly buoyant so that it would float.

This is the forming operation. They do a lift of about 10 or 12 feet and just keep making those pours.

Here you can see them without the couplings. If you are not familiar with caisson construction, there was a barge-mounted crane with a big clam bucket on it. The operator keeps reaching down inside and mucking out material. As he does, they try to get it down to those cutting edges. They actually have a sharp point to come down to a V shape on the bottom and we just keep pulling material up and jetting it a little bit if we need to. The caisson just keeps going on down as we add weight on the top.

Getting ready for another lift, you can see the cutting edge fully submerged now. We are now placing concrete and just taking it on down. This also shows the cell again.

This shows the reinforcing steel for the distribution block. At the bottom of the caisson when we got it down to the final elevation we sent a diver down in both the dredge wells to make sure the bottom looked good and was material we did want to found on. Then we started tremieing concrete in there. We put a 20 foot thick concrete seal on the bottom of the caisson. Then we came up to the final sunken positioning. We put in the reinforcing steel. There was some precast concrete covers that were about 2 or 3 feet thick that fit over those dredge wells that basically became forms for the actual top of the caisson. Then a 10 foot thick cap was poured on top of this. The walls of the caisson are about 5 feet thick.

This shows some of the forming again. The last pour of the water was kind of high and we were a little concerned about water getting into the pour. So what the contractor did was pour a really thin wall all the way around the outside. He raised it up about five feet so that we didn't have to worry too much about the water elevation during our final pour. Then they went ahead and did the form work and ended up pouring inside the rest of the distribution block.

Here you can see now the distribution block has been poured. You can see the steel for the actual pier stand. One of the caissons landed within two and a half inches of its desired

location in both directions. The other one was within six or eight inches. They were both quite close so we had real good luck. We really didn't have any scares with them.

Like I say, this was a first for me so I wasn't sure what to expect but it all went pretty smoothly in this case.

Here you can see the distribution block again. They are starting to tie up their steel for the pier stem and everything. This will get one of the truss spans on top of it.

This may seem a little disjointed, but I am trying to show you the order that we did the whole project.

While we were doing the substructure, once we got into that, we started letting dirt work contracts.

This is what will be the south connection to our existing main line. It goes south to the new yard I was telling you about. The new alignment will take off and then curve over to the north and this is in preparation. What we ended up doing eventually when we got ready was kicking the main line over and then operating on that while we came over with the new main line. Then we ended up leaving that over there.

That is now our connection. We still have a spur track going into Alexandria from this location so we are still using the track. It's just a stub-ended track. Of course, when we were done, the natural position of switch is going through the curve.

This is the turnout side.

This picture shows some more dirt work on the south end. There was an old bayou in here. We ended up putting in culverts. We had to do a lot of mucking in here to get any kind of foundation at all. Some of these areas in Louisiana are just silt forever. It goes on and on. I think the whole state is just old Mississippi River bottom.

This shows the south approach again and it shows wick drains. I don't know if many of you have experience with this. Again, for me, it was a first. It looks like a flattened out fire hose. They have a machine that comes in and inserts it way down. What it is is a big bed of sand. We lay a couple feet thick layer of sand out here under the entire south approach where the fill was fairly tall. Then it inserts the wick drains down into the ground. There was a whole forest of these things. Once we had that done, we start placing our fill material. Like I said, the fill got to about 25 or 30 feet tall in the south approach. As you started adding all that surcharge, it squeezes all the soil underneath and that pressure forces the water up these wick drains. It comes up just like it would in a candle wick. We have a clay layer above that to seal it. So it hits that sand layer and bleeds out the side. You get that moisture out and you get a lot quicker and better consolidation of your soils underneath. It really works slick.

We got the south approach and fill up and in place in 18 months or so before the construction of the whole bridge was completed. We got most of our settlement out of the way before we put our ballast up there. So it really worked well.

This is on the Pineville grading on the north approach. It is just one of the fill areas. We had some pretty substantial fills. Most of these were laid at about three to one slopes which is pretty much a minimum in that part of the world. We did a little lime stabilization but not very much actually.

Here we are back on the south approach again. This is the select material laid out here. We are coming up with what will be the bridge abutment.

Meanwhile back on the approach bridges, they were getting ready to put the slabs on top. You can see all the rebar and they are bringing some more as well. We used stay-in-place forms here. We just fastened between them. You can see the AASHTO beams with the sheer steel sticking out of it. You can also see the reinforcing for the curves.

This is the pour taking place. Obviously they pumped the concrete in here from down on the ground. We had pretty good access. We built quite a few access roads so that was not much of an issue.

This is the south approach pretty well finished and ready for the track construction. The caissons, by the way, went to about 60 feet below the river bottom. We found some real hard stuff down there and we were able to live with that.

Now you can see that they have the south abutment in. They obviously had to have some of the fill up there before they could finish that off. The filling work in this area was timed to work out with the bridge contractor's work. We had written in each of the contracts for the contractors to coordinate with each other.

This is the north approach all completed and just waiting for the steel spans. You can see where the water line was. We built a slab over the road to make sure we didn't get any heavy wheel loads that might damage that water line. Then we put a guardrail in to make sure everyone went through at the right location. We didn't want anybody getting off of that slab and damaging the water line.

This view is from the north abutment looking south towards the river.

This shows the piers for the major truss and girder spans finishing up under construction.

These are the finished river piers waiting for the spans. You can see the cells are all done. The walkway is out and navigation lights and everything else is there as well.

This is the other caisson and pier. Note the clearance gauge for navigation. We thought it was kind of funny for a fixed span and we asked for waivers from the Coast Guard. These signs are surprisingly expensive. We thought for a fixed span why do we need to go this far. For the water to get this high, the entire state of Louisiana would be under water. They said we had to have that. I think really what they wanted was geared towards a movable span but we couldn't seem to come to agreement on that. So we ended up buying the sign all the way up.

This is an aerial view to give you an idea of what we were working with. This is the Pineville or north approach. It is where most of the seven miles of realignment was to get to the new location.

This is another view of the dirt work pretty early on obviously.

This picture shows another fill area. We had already started some slope stabilization. We had some pretty substantial cuts as well. That stuff down there just runs and we had a hard time stabilizing some of these slopes.

This is one of the secondary bridges I talked to you about. It is basically a prestressed concrete structure.

Here we are placing steel girders and now we get into the trusses. You can see we used the stiff leg. They drive some false work out in the river, put some posts up to hold up a location, and then they drop these diagonals. They put another post up to support another panel point. That's how they erected the truss. Stupp Brothers out of St. Louis was the fabricator and Beasley was the erector. I give a lot of credit to Beasley and I guess most of you know that they have since gone out of business. They were hurting financially and we knew it at the end of the job. They purposely waited and finished out our job and then they declared bankruptcy the next day. They really did good by us. It could have caused us a lot of heartache.

You can see the false work and the posts to build this. For fall protection they, of course, hung that in.

This depicts some of the false work spans out in the river again getting ready. This was all, of course, coordinated by the Coast Guard.

This is another one of those stiff legs assemblies. I had never seen a truss assembled out in the middle of the river like that. I had been involved in quite a few float-ins, but not a high level crossing assembled up in the air like that.

Here they are coming right along. There is a completed truss. The two big trusses were 355-foot spans each and the shorter truss was 190 feet. We also had six 125-foot deck plate girders, 150-foot deck plate girder, and the remainder of the bridge which was almost 5,000 feet long was the prestressed concrete spans.

Finally, we came in with the track work. We decided to go ahead and go first class on this. We supplied all the material and everything but then we had Holland come in and do flashbutt welds on all the field welds for us. I don't know if you have seen their portable unit, but it's a pretty slick operation.

We almost forgot one thing as far as the Coast Guard was concerned when we turned in our first schedule to him. We had this big meeting lined up and we showed them all this information for the bridge. We forgot, however, to put demolition of the old bridge. That's all they were really concerned about. They couldn't care less whether we built a new one. They just wanted the old one out of the way.

This is drilling for demolition of the old piers and we are blowing the old piers. The steel was disassembled by the contractor who was building the other bridge. He used the old main line to bring in some of his steel beams for this bridge and then when he was done with that he blew the old structure.

This is the finished product. This is the north end of the project where we tie into the existing main line. It shows some of the track work along the north approach. This is the north approach to the bridge. Of course, it's all ballast deck.

Again, this picture is looking south from the north end of the bridge. For truss spans, we elected to go open deck. We looked at ballast deck but this line is about 16 million gross tons. We were getting to a point cost wise with what we were spending that we just couldn't justify the additional cost. So we decided to go open deck on the trusses.

This is the south approach all finished up looking back to the north from the south end of the bridge.

Here is the completed span over the river.

The bridge took about 22,000 cubic yards of concrete, 100,000 linear feet of H-pile, 15,000 linear feet of prestressed beams, and about 5,706,000 pounds of structural steel. The total cost of this project including the earth work was about $25 million or so. The bridge itself cost about $20 million which worked out to be about $4,000 a track foot.

Thank you very much. If anyone has any questions, I would be glad to answer them. (Applause)

Member: How long did it take to finish this project?

Mr. Franz: We started in December of 1992 and we finished in February of this year.

I would be remiss if I didn't thank a couple of people. Bridge Form and Associates was the consultant out of Dallas, Texas, and they did all the design of the project for us except for the truss spans. We hired Howard Needles out of Kansas City to do those. They did an outstanding job.

There is one thing I should mention, I gave you the cost but one thing that was interesting to me was that we came in with a final cost at one percent less than the bid cost. So our change orders were actually in the negative. I think that is a credit to them especially with the type of construction and with all the substructure work we had and all the things that could go wrong. The fact that they could do that and still come in actually under the bid prices was a real credit to the engineering, the thought that went into it, and also the contractors that really did a good job for us. So thanks to all those people who helped us out. It was a very successful project. (Applause)

Mr. Franz: Our next feature is entitled Hard Rock Boring and the presenter is Karl Benzer from Utico Hard Rock Boring company.

Mr. Benzer is a graduate of the University of Rhode Island with a Bachelor of Science degree. He has over 22 years of experience in the drilling business. After a 20-plus year career in the oil and gas business, he joined UTI Energy Corporation to promote and operate their proprietary horizontal rock boring process.

Please join me in welcoming Karl Benzer. (Applause)

HARD ROCK BORING

Karl Benzer

Utico Hard Rock Boring Company

Text Unavailable.

Mr. Lileikis: Thank you, Karl. And thanks to all of you who gave presentations this afternoon. Don't forget to complete the conference survey form and turn it in before you leave.

At this time, we'll adjourn to the Wellington Room where Jolene Molitoris, FRA Administrator, will speak.

(Adjourn)

President Bradley: At this time it is my pleasure to introduce Ms. Jolene Molitoris, administrator of the Federal Railway Administration.

Before joining the FRA team, Ms. Molitoris served eight years as deputy director of the Ohio Department of Transportation. In that role, Ms. Molitoris is credited with developing a proactive nationally recognized rail program. She also successfully established 13 new Ohio shortline railroads and created an industrial development program affecting 220 industries and nearly 40,000 jobs in Ohio.

From 1987 to 1993, Ms. Molitoris worked for the Ohio Rail Transportation Authority where she progressed from the assistant liaison officer to deputy director in three years. During her final year with the Authority she attained the executive director position and managed all freight and passenger railroad programs in Ohio. Ms. Molitoris worked on rail issues on both the state and national level. She served two terms as the region chair of the national conference of state rail officials and was the 1989 and 1992 recipient of the high speed rail MagLev Association President's Award for outstanding achievement.

Ms. Molitoris is also a recipient of the 1995 Women's Transportation Seminar's woman of the year award from the WFTS, Washington, DC, chapter and the 1996 Women's Transportation Seminar Award for woman of the year for the nation.

Ms. Molitoris holds a B.A. from Catholic University of America and a Master's from Case Western Reserve. More importantly, she is a Columbus resident. (Applause)

KEYNOTE ADDRESS

Jolene Molitoris

Administrator
Federal Railroad Administration

Thank you so much, Mike. It is really a pleasure to be here. I haven't seen you in this forum for two years and we really have a lot to talk about because a lot has happened in those two years.

If you were here in 1994, we talked about the possibility of a Roadway Worker Safety Rule. We talked about some of the initiatives that FRA was strategizing about and how we were trying to change fundamentally the way our programs operated. I don't know how much of that you remember, but I can tell you a couple of things. First of all, when I took this job in 1993, I took it because I believed that the President was committed to rail transportation. Although it's great to be the Federal Railroad Administrator any time, it's really great to be the Federal Railroad Administrator when you work for a President who loves trains. I suppose most of you saw the 21st Century Express in August. I was fortunate enough to be part of the President's team on that trip and it did my heart good to see that rail transportation was being broadcast all over the world as the mode of choice for this President.

From 1993 when I arrived, this President has given 100 percent support on all the programs that we have been developing to promote safety and to promote rail transportation in this country. If you recall, the first bill in the first 100 days was the High Speed Rail Bill that the President promoted. His budgets have consistently invested in Amtrak at a much higher level than any of his predecessors. He has for the first time chosen to make highway rail grade crossing safety a national transportation priority. He has given us an extraordinary level of support with regard to our efforts at working cooperatively, jointly, and in safety partnership with labor, management, and suppliers. I think the Roadway Worker Safety Rule is truly an example of what we can do when we work together.

The changes that we are making at FRA, I want to emphasize were not something I dreamed up in an office in Washington. The direction we were given was plain. The President said to us the right answers to our problems exist at the front lines where people are doing this business every day. They know what the problems are and they know what the answers are. Going to them and listening to them is going to help you produce common sense solutions to the kind of safety issues that we are facing.

So at the end of 1993 and 1994, I held ten administrator's round tables and the purpose of that forum was to have labor, management, and FRA as well as suppliers and our customers sitting at the table with us to focus on a particular issue whether it was track, HazMat, operat-

ing practices, or whatever it was. We sat there with brown bag lunches for three or four or five hours to talk about what problems were being faced by all the different entities. Perhaps you recall that the initial administrator's round tables were challenging because that environment, labor, management, and FRA, had not been one historically that had been extremely positive. It normally generated a few sparks. So it took us more than a year to develop the kind of trust and respect that is absolutely necessary if you are going to work to successfully negotiate on anything. I think it's very important for me to say up front safety is not a negotiable issue.

It's important that when I say negotiated rulemaking, you don't think about contract negotiations. That is a separate issue between labor and management. What we have made an effort to do with your help, with labor's help, and with the supply community's help is to identify that we have safety as our common bond. Truly if we are going to increase safety in the railroad industry, we can only do it together.

When we talk about 1996, we talk about a construction season in which you have voluntarily implemented the Roadway Worker Safety Rule while simultaneous with it going through the regular system. I want to congratulate those of you who have been real leaders in this. But before we talk about the actual experience that you have had this year, I would like to be sure that you understand the genesis of this whole rule. We had spent about a year working together to create safety partnerships. Sometimes they were maybe small things to some people. For example, I just came from Indianapolis and the RSSI convention and this is my fourth convention with them. When I first came to the FRA and I asked our signal and train control specialists and inspectors when they had last been to the suppliers and the research and development labs where all the new products were being created, they said they had never been there. How can that be? How can you know what is going on with the cutting edge new technology that is really exploding in the rail industry if you are not there firsthand seeing what is happening?

So a partnership emerged in which we cooperatively established training programs at every major signal and train control company in this land. All of our people went there and saw and heard what the vision was and understood in a new way the kind of products they were inspecting. They established a working relationship that has truly been beneficial and added value to us every day in their work life.

The Roadway Worker Safety Rule, which will be a final rule we believe next month, was one that grew out of the fact that it was a life and death matter. We were losing too many lives out there on the railroads. Something had to be done. So we made a decision to break this particular element out of the major rule and treat it separately and on a faster track.

We also believed that the President's challenge to us to do business in a new way gave us an opportunity here with such a crucial issue to try the negotiated rulemaking. We had to because of government regulations to establish a special committee just to do this work so that it was all in the sunshine. No behind closed door negotiations. We chose people who understood this business and people who have a vested interest. That is, labor, management, suppliers and FRA. In fact, there were, I believe, 12 labor, 12 management, and 1 FRA. It took a few meetings perhaps to get through a little rhetoric. You know if you have ever been to a FRA hearing as a result of a Federal Register Notice that everybody has to give the story, you know, the truth according to whomever. Everybody has their litany of issues.

While I was waiting to be confirmed by the Senate, I spent a little time reading records of testimony. You know it was really kind of amazing because if it was 1986 or 1988 or 1990, you could almost predict what was going to be in the record by whatever group because it was often the same. So we had to establish an environment that said we want to clear away the rhetoric. We really want to focus together on what the safety issues are in terms of the lives and the safety of roadway workers and their work on the railroad and their safety and their ability to stay alive and stay well.

It really was encouraging to see that evolution. Gordon Davids is here and can tell you just that. It became apparent that they had much more that bound them together with regard to

safety than divided them.

It doesn't mean that it was easy. If anybody tells you this negotiated rulemaking process is easy, tell them they have never been part of it. It is truly hard, difficult work because the goal is to reach consensus. We defined consensus as ending up with something you can live with. Surely you know that it is never 100 percent of what you want. So everybody has to give. Everybody has to move. Everybody has to hear nuances from another person's point of view and it really is a different way of working

I can tell you that on May 17 of last year we sat in the Secretary of Transportation's conference room. Twenty-five people sat around that table and presented to the Secretary a signed document acknowledging their consensus on the major portions of the rule. It was truly a victory of incredible proportion.

I remember with some poignancy, I must say, two gentlemen who were sitting next to each other at the table and when the Secretary asked for comments from the group, what we heard was, "Secretary, you don't know us but these other people do. We are sitting next to each other on purpose because when we came into this thing, we were mortal enemies. We always had been. We had been fighting for years. We are sitting next to each other because we are proud of the fact that we have done this together. We have learned something about each other. That is good. We respect each other in a way we never did before." It was really quite a powerful moment. You know someone said recently and I think it's an extraordinary thought that you might want to consider and that is the currency of the 21st century will be relationships. I think that this negotiated rulemaking process really showed the power of relationships, the power of commitment to safety that overrides all personal agendas.

Once the rule was signed, we had to put it into the proper format to get it started on the normal way of doing business with traditional rulemaking. We had to go through a lot of channels. When 1996 came along, I sort of think of it as the best of times and the worst of times. Because as you know, 1994 and 1995 were statistically the safest years in railroad history and we were feeling really good. The programs were working. The safety partnerships were working. We have increased safety over two years.

Then February 1st, 1996, happened and my phone rang and my life will never be the same. Actually neither will yours because that was Cajon and the beginning of six weeks of the most tragic circumstances in the history of this industry. All of you, I hope, are aware that our history truly is changed because the spotlight, the environment, the analysis, the scrutiny is bigger and deeper and broader than it has ever been.

FRA has some very strong authority. One of them is the emergency order. It hadn't been used in five years; however, within a period of about six weeks, we used it three times. Because we had to. Because it worked. The emergency orders addressed specific issues at Cajon — specific issues in the commuter incident in New Jersey and Maryland and it also addressed a bridge in Tonawanda, New York.

However, emergency orders are temporary answers. They are short-term answers and so during the course of six hearings on the Hill and many, many other meetings, we needed to look again at the very foundation of what we were doing together. The challenge and the bar on safety really became raised. One of the things we learned from those six weeks and we began to testify about vigorously is an issue that probably wouldn't be the very first one that comes out of your mouth when somebody says to you, "How can we improve safety?" You are going to pick up one thing. Maybe it's more track inspection. Maybe it's more ties. Maybe it's a lot of other things that you do every day. But if I said to you the biggest thing you can do to change the safety environment is communication, what would you think? Would you think that's kind of a soft subject? That's not very technical. That's not very hard news. What is this about communication?

Well, let me tell you that railway worker safety and your work on this issue in the past construction season and now has as much to do about communication as almost anything else.

I don't know where Mr. O'Leary is in this crowd. Are you here? Hello. I want to tell you that you are a hero in my mind because in this area, Conrail stepped out first. You didn't wait until we said you have to. You knew that it was going to increase the safety of all your roadway workers. You moved with dispatch and, as I understand it, you are really the one that made it happen. I know you're part of the team, but what happened on Conrail is now happening on railroads all over the country. All are to be commended, but I want to tell you I was out with track gangs on Conrail about six weeks ago. What I heard from them was truly exciting, because the rule is out there.

You have seen the drafts, the notice of proposed rulemaking. You are going to see the final rule next month, but what I want to emphasize to you is that if you only do the letter, you are not going to get it done. Because you can hand somebody something to read, but that does not guarantee that all of the elements are going to work well on your railroad. It doesn't guarantee that the people understand it. It doesn't guarantee that they see you as a role model for the spirit of this Roadway Worker Safety Rule.

What we learned during those horrific six weeks, Cajon is a perfect example, is that many, many people of good will and good intent didn't get the message either going up or going down. One of the reasons I made such an effort to be here today is in my book you are key to making this happen. Because what we have learned is the policies of the railroad are focussed on safety. They believe it. They mean it. They make capital investments to back it up. But somewhere in the levels of the railroad, somewhere there is a gap. I think that the people in this room can make sure that there is no gap.

How do you do that? Number one, you have to look in the mirror first. How important is safety to you really? Does it guide everything that you do? Is it first and foremost from every other consideration in your job? When it comes to roadway worker safety are you going to be sure that it's a team effort? Are you going to be sure that your employees are at the table with you as you design your program? One of the things we gave to you is the opportunity to design the right program for your railroad. It gives you some flexibility. But if you operate like the old FRA and design something in a management conference room and then hand it down from on high, it's not going to work in the same way that Conrail's works. Because those employees were involved. Not only the letter, but the spirit of the law is alive and well at Conrail as far as I saw.

I went out on three different places on the railroad. We had to take special transportation to get there because it wasn't, you know, downtown Pittsburgh. But my objective was really to hear from these actual working men and women. How does it make a difference in your lives? So it's the Roadway Worker Safety Rule and they are doing it and so what for you.

Once they decided they were going to talk, first of all, it was truly exciting. One of the things that was so exciting is that they said even more than I expected to hear. They said, yes, safety has become a priority since Roadway Worker Safety in a way that it never was before. We like the way management is talking to us about this and is listening to us. We feel safer. We like the ability to have the authority to protect ourselves. We appreciate the opportunity to challenge an environment if we don't think it's safe. We feel like we are part of a safety team in a way we never did before. I will tell you, I think that is a big tribute to your program, Mr. O'Leary.

I would challenge each of you, and I presume all the railroads are here, that you are as responsible for the success of this program as any agreement employee. There is nothing that infuriates me more than when you talk to any management person at any level about a problem and they say to you, well, the rule is there, they just didn't follow it. I am not a happy camper when I hear that. Because this is your railroad and this is your industry and every single person is responsible.

What kind of plan do you have to assure that your employees understand what this rule means? How do you guarantee the structure of your railroad? You have a method to assure the

integrity of your tracks. It is just about a guarantee. I think that you need to have the same kind of guarantees in whatever program you have designed or will modify in its design.

We have a few months left of construction season and I hope that people don't think that the rule is going to be out in October and we did it this year and so it will just happen. Like safety, it's an every day thing. I hope that the people who are in charge at the other railroads besides Conrail, and I presume given the fact we are highlighting Conrail so much you are going to make it even better next year, will have an opportunity at the close of construction season to evaluate the successes or the challenges of the program this year and that you will be able to think about ways to incorporate the advice and counsel of your employees.

I will tell you FRA is a better place because everybody who has a vested interest is at the table. We are stronger because we have the advice and counsel of labor just like we have the advice and counsel of management. I think as we look forward to the years ahead, we would be shortsighted if we didn't understand that partnership is the only way we are going to get it done.

We have a zero tolerance goal. What other goal can we have? It's your goal, too. No accidents. No injuries. No deaths. Twenty years ago they would say that's impossible. It's just a price of doing business. I don't think so. When you look at the numbers and the statistics now, you see how far the industry has come through technology, capital investment, and a commitment to safety that is far different than it was 20, 15 or even 10 years ago.

Safety is really a personal thing. It has to be number one on everyone's agenda. It is a way to make your railroad successful. I will be continuing my visits to railroads and to their track gangs because I want to continue to get input from everyone about what it really means out there.

I was so interested in one of my Conrail visits. A man came up to me and said, "You don't know me and I am not an employee, but I am a contractor. I want you to know that I feel safer in this environment. I feel safer and I didn't realize it was going to affect me."

As all of us evaluate the way we are going to do business in the future, contractors are a part of the life of the railroad. Their involvement and their level of understanding that they are responsible to you just like your own immediate employees is a crucial factor in reaching zero tolerance of any safety hazards. We are working with the Railroad Contractors Association. We are working on training. We are working on communication issues. So there really is no part of this industry that can be left out of the successful answer to the safety problems that face us.

I would very much like to have a few moments if I might, Mike, to have a dialogue with anyone here that would like to comment on roadway worker safety or any other issue. I think it would be helpful for me to hear from you some of the experiences you have had and any advice you might have as we move forward throughout this year in terms of roadway worker safety or any other issues on your agenda.

Member: When will the final notice be out?

Ms. Molitoris: We expect the final notice of rule will be published in the Federal Register in October. I think that you will see substantively the same rule that came out of the negotiated rulemaking process with some ticks and nuances. We added some comments to the docket, but not a huge number. That is, again, part of the success. It keeps it sort of focussed on getting done and we do have a stronger rule I think because of it.

We are working with the Shortline Association and they have a final draft of applicability to shortline railroads and that will be coming out soon. There is some change since there is a very great difference between the Class Is and your railroad. But it is and will be applicable to all railroads.

I have one last word. As you probably all know, as a result of the success of the negotiated rulemaking on roadway worker safety, we said this is a better way to do business. We established a standing committee, the Railway Safety Advisory Committee, which is now doing four simultaneous rules through negotiation. One of them that I know is most crucial to

you is the Track Rule. We have been very encouraged by the progress that has been made in the track working group.

The next railroad safety advisory committee is going to meet I believe the 30th and 31st of October. At that time these working groups on the four rules are to bring their recommendations to the Railroad Safety Advisory Committee. Then the decision of that advisory committee will be either to approve and send it on to me or for some reason to send it back to the working group.

We really are hopeful that consensus can be reached by the end of the month on these four rules. It's not an easy process. I think the track people have done an extraordinary job. If any of you can be supportive of your representatives on that committee I would encourage your involvement and your supportive comments to them.

I thank you for inviting me here. I will be outside in the lobby for a little while and maybe those of you who are perhaps a bit hesitant to make a statement in the public forum would like to give me some good ideas in a one-to-one situation. I would be appreciative of that.

Mike, thank you. It is a good opportunity for me and I appreciate it very much. Thank you. (Applause)

President Bradley: Thank you very much, Jolene. We are going to ask you to stick around for a few minutes. Kendall Koff, president of the Roadmasters is going to take the podium and would like to address you.

President Koff: I would like to express our thanks again for you to join us today. You were an invitee of B&B, but the Roadmasters also has had the benefit of your company on two occasions here in Chicago and we certainly appreciate it.

As a little remembrance of your time here we want to give you a hat and a little roadmasters' pocket knife.

Ms. Molitoris: Thank you.

President Koff: These are excellent tools for cutting filter fabric and other little things that we do alongside the track.

Ms. Molitoris: I can practice on the railroads. Thank you very much.

President Koff: We do very much appreciate your being with us. We would like to also offer, and hopefully you'll accept, a membership in Roadmasters as another little token of our appreciation.

Ms. Molitoris: Thank you very much. If it's legal, I'll do it.

President Koff: Joe Riley and a group of his compadres along with a number of rather dedicated workers in our training committee have put together a symposium that went on this Sunday on experiences in the track worker safety. They put together a lovely little book and we'll see to it that you get a sample of the product that we shared at this symposium. It was an opportunity for those who attended to share their experiences on how they implemented, what their training was, and where it went. The goal, of course, was to use these shared experiences to see what worked, what didn't, where the bumps were, and hopefully through the shared communication make the thing even better in the future years.

We'll see to it that you get that. Thank you for being with us.

Ms. Molitoris: Thank you.

President Bradley: Provided you don't have any tax problems we were as well going to offer you a membership in the B&B Association, but you can run that by them first.

I noticed that you said in your address that these people were the key to the success. We also feel that you are the key to the success. So we have a switch key here that is on a key ring. It has the B&B logo on one side and it has the Roadmasters logo on the other. I did want to point out to everyone in the audience that the B&B is on the front. (Laughter)

Ms. Molitoris. Thank you very much. It has really been great. I appreciate it.

President Bradley: We will adjourn until tomorrow morning at 8:00 a.m. when we'll be in joint session with the Roadmasters in the Wellington room. Thank you.

JOINT SESSION

Tuesday, September 24, 1996

Opening Remarks

President Koff: I would like to share with you that we have over 600 folks in attendance and that's just excellent. That is about what we expect in a nonshow year. I think there is really good reason to be pleased with that.

We have a real treat for you today. I would like to tell you a little bit of history here. I am with Amtrak now but my background stems from the Chicago & Northwestern. Everybody has a little soft place in their heart for the road they started with. With today's mega mergers we all started with somebody other than who we are with today it seems. As I said, my history goes back to the Chicago & Northwestern and through that there is a good number of officers up on the Wisconsin Central so I have kind of adopted that as one of the roads for which I have some positive feelings. I have a number of associates up on the property whose acquaintance I count as a blessing. They are just an excellent group to have.

With that said, we have a gentleman by the name of Mr. Earl Currie from the Wisconsin Central here with us today. As an Amtrak guy, I wanted to give you that little preview of how we got the Wisconsin Central here to speak this morning. I want to tell that you Amtrak is one of the two roads they are not looking at buying right now so there is no connection. (Laughter)

Without further ado I would like to tell you a little bit about Mr. Currie's background. He started with summer jobs on the Great Northern Railway including work on its steel gang, rail gang, and basic production gang. He advanced through the chairs of the operating department of the Burlington Northern including positions such as trainmaster, superintendent, division superintendent at Missoula, Montana and Lincoln, Nebraska, assistant vice president operations in Chicago, vice president and general manager in Seattle, vice president operations on the Soo Line, vice president engineering for CSX, and vice president and chief of transportation officer for CSX.

Mr. Currie currently is vice president planning for Wisconsin Central. I am very pleased to have him with us today and we look forward to hearing him talk. (Applause)

KEYNOTE ADDRESS

Earl Currie

Wisconsin Central

Thank you very much, Ken. I appreciate the chance to be here. Ken didn't mention that this invitation was on short notice. I am still glad to be here, but it feels like being back on the extra board again. You never know when you are going to get called, but you have to be ready for anything. Also I thought of the transportation side and the provisions for claims for short calls. I don't know what I can do to collect from the organization for that, but keep that in mind as I talk. (Laughter) This was put together rather hurriedly. When I got here it wasn't really difficult to do because you always enjoy talking with railroad people who are close to the business especially a group like this who is right where real stuff happens. But I roughed out these

notes during last night's Monday Night Football so if there is a little lack of coordination here, please forgive me for that.

I am glad to be part of the B&B and the Roadmasters and Maintenance of Way Association. I think it's good you have been able to keep things going to get over 600 people registered. That's outstanding especially with all the continued change there is with the mergers Ken mentioned and the downsizing and never-ending restructuring as part of today's business world.

I have always enjoyed working with people who are involved with MW&S work. I am going to use that term. We always use terms which we are the most familiar with or what we grew up with. We all have a soft spot for the railroad we started at like Ken said. We all started somewhere and we tend to bring along the old term. MW&S is the one I am most familiar with, that meaning maintenance of way and structures. I always found the maintenance of way people to be solid citizens of the railroad, excellent supporters dedicated better than anyone else. Your families knew how hard you worked. There are disruptions that you take to family and you do whatever it takes to keep things going no matter what is going on in the organization. I have always been impressed by what the roadmasters, B&B supervisors, division engineers, and so on do to keep things going on no matter what else is going at the financial or corporate level of an organization.

I consider myself quite lucky to have had probably more exposure to maintenance-of-way work than many people who have had the career path that I have had. I don't mean to say I am an expert because I am not, but at least I know enough about it to be able to manage it to some degree. One reason I had as much as I did was that on the some of the roads that I worked for in the past the division superintendent had responsibility for maintenance of way and structures functions. I think that's not only an excellent or desirable thing, but very necessary also. Most organizational structures and railroads now have the mechanical and the engineering or maintenance functions separated from the general manager or the superintendent level. I know there are some that still do and I am glad there are, but I think we are training people who are going to advance to senior levels. If they have had to manage maintenance of way work, they at least understand it. It can make a heck of a difference from knowing only how to run trains and switch cars. So that kind of organizational structure, if you have any influence at home, is something that needs to be reviewed and let the pendulum swing back to where it used to be in more railroads.

Another advantage that I had in my career was that I was part of Burlington Northern during the years when we were pouring massive amounts of money in to rebuild the railroad to handle the Powder River Coal Basin. That was a lot of fun. It was hard work, but it got you really close to the maintenance of way people because you were betting the company on the money that was going into that. Of course we all know what the rewards have been for those who participate in that traffic today. The Union Pacific and Burlington Northern Santa Fe benefit in particular. So that massive rebuilding was fun and it may be an opportunity that may be never repeated in this industry. I sure count it among the best experiences that I ever had.

Today I want to move ahead and share some ideas that I have on where I think MW&S work needs to be going to ensure that we meet the needs of today's railroading. This is not going to be technical. You have plenty of people following me who are good at that. Gary Wolf was visiting with Darrell Cantrell a few minutes ago and I saw some others on the program who can carry that off far better than I could so I am going to talk about more of the general managerial area and some nontechnical things which I think should be of priority for today's MW&S officers.

The first thing I want to talk about is safety. Your commitment as managers, as leaders, of the MW&S function toward continued improvement and safety. Secondly, leadership of your people, your organizations, and thirdly your support of service as provided on your railroad.

In the area of safety, much has been said and deservedly so about the fantastic improvement that there has been in employee safety in your industry almost across the board in the last five to seven years.

A very general number puts it in the magnitude of a 50 percent reduction in the frequency rate. That is absolutely outstanding but it did not come without a lot of hard work. It's very commendable and has really raised the stature of our industry. Of course the people who benefited from this the most are the employees doing the work. More and more of them are able to finish a tour of duty and get home in as good shape as they were when they first came to work. But of course we all know that to sustain that kind of improvement takes work. There can't be any complacency. If you take your eye off the ball, it's going to bite you. Every day you have to have a mindset that says what you are going to do for safety today and make it visible to those you associate with. Any failure to do that leads to complacency and very quickly safety can deteriorate. When we start that deterioration, look yourself in the mirror and ask yourself if you are doing all you can do for safety and you will probably find you have slipped some. You haven't been emphasizing it. You haven't been as visible. You let secondary things get in the way.

But for now let's take a great amount of pride in what we have done for our people in the maintenance of way area and across all the other functions in railroading in America. It's really amazing. In addition to maintaining the course to avoid complacency, we have to focus on the unsafe acts. This is getting to the base of historic times that we are all familiar with, managing safety. The unsafe acts in which nothing happened this time but it could have. The big opportunity, I think, in heading off unsafe acts is the pure intervention that can come from the leadership of the safety committees and from the skilled employees who have bought into safety and who understand what it means and that it's a way of life. With peer intervention as a major part of an effort to stop unsafe acts is a level that I think we have some opportunities in order to sustain the improvement that we have and to further drive our records to a zero level on a sustained base basis.

Work on the attitudes of people. Not all the people have bought into what we have done on safety. Some think it's a game yet. They think it's a management game. It's not for their benefit. At least they don't see it this way. They are harder to turn around than others. Some can be people who lack skills. Some can be those who have attitude problems and they bring those attitudes to work or problems from home and they are therefore open to exposure for unnecessary injury.

So, this buy into safety is a way of life. There are those who are not yet believers. I had a boss who was probably the best person I worked with on safety, Jerry Davis, who compared safety to a religion. As you get closer and closer to it as all of you have, you probably feel the same way. It's a part of you. This isn't something that you turn off and on, but there are some who haven't reached that level yet. They are the ones you have to be concerned about because they are still subject to injury.

As I said, never figure that you have it made because you don't. The way we handle safety today is more affirmative and I think a more mature way than we used to in the past. All of us can tell stories about how we have seen safety managed by people in the past. I think there are different ways of doing it as times have changed.

One of the first jobs that Ken mentioned that I had during the summers while going to school is to work on what we call a steel gang. It was actually a rail relay gang on the Great Northern Railway. Some of you probably know Don Rogers who is now retired from BN, although I heard last week he is putting in concrete ties now on the Stampede Pass, so he is not really retired. Anyway, Don was the boss of that steel gang and he was tough. He had to be with the group that he had and the nature of the work. I remember the first day I walked out on that gang. We were starting before the sun was up at about 4:30 a.m. He came up to me and said, "I don't need you on this gang. Of all the people I need, I got you." He said, "Don't you

dare get hurt." That was the safety orientation, but it worked. People didn't get hurt on that gang. A couple of guys did and they were threatened with having to work in the kitchen instead of outside and nobody got hurt. That was it.

But this whole concept of orienting people and saying this is a safe place around here needs more. If you can't work safely and can't take care of yourself and take responsibility for safety, you don't belong around here. We will train you. We will give you good tools. We will give good safety programs. We will give you an opportunity for communicating upward on safety issues. That sets the whole stage so you can be a safe worker. Now you have to take responsibility for yourself from here because absent other input from you, we have done our job to make that a safe place to work.

In the area of leadership, it's important that railroad management respect the work that you have to do as MW&S officers. You have to work in all kinds of weather. You have to make judgments. Some of the judgment that you have to make I think are awesome in terms of, for example, is this track safe for passage? Is it the right time to get out and inspect after major work is done? Is it okay now to have tracks pass at a given speed? Can we raise the speed? It's quite an awesome responsibility. When you think of a steel gang or rail gang finishing its work, and I know there are different standards of what speed is allowed after so many tons or so many trains or so many hours may have passed, but when you have a train going 79 miles over newly finished work with a gang or a collection of people you have to manage to do things safely, that is an awesome responsibility that you have and you should be respected for that.

There are very few people who are qualified to make these judgments. Those who are trained to do it and will accept the responsibility to make these judgments know their stuff, know the standards, know from experience and deserve a lot of respect for that. Given that you have that importance in the organization, it's very important that you can demonstrate to your people and also to others in the company that you know your business and that you keep your word. You must deliver what you say you will. You can build trust by knowing what you are talking about and being able to keep your word. You build trust from the work force and from your bosses. Do what you say you will do and, of course, practice what you preach. As some of you say, walk the talk. Set an example. People will respect you even more and you will probably be more effective in getting across what you know is necessary for a safe and more service oriented, more service focussed operation.

Tell people in the company what you are doing. I found a lot of maintenance people hold back much too often on this. They are doing a lot but they tend not to communicate it. It is necessary for the company to get an understanding of what you are doing and what you are up against, but also the successes that you are having.

You really maintain the foundation of the company. You maintain the foundation for safety as well as for service delivery.

Support your people. I know you do within your own function, but demonstrate that you support your people. Some of you may have seen an article in Trains magazine about a month or two ago where it mentioned that maintenance of way people are still treated as "coolies." That made my blood boil. Conditions have improved. Sure, the work is not easy. It's never going to be easy, but goodness, give us some credit. Give your own people credit, too, and the rest of the organization whether it's the finance people you have to deal with, the marketing folks, the human resources, or employee relations side. Support your people. Don't let people be considered second class citizens because they do hard physical labor. In addition to hard physical labor, which we still have plenty of out there, we have people who have to know a lot in terms of handling today's computer-based equipment and computer-based maintenance planning.

There are not as many railroad presidents to date or vice presidents of operations who came from a background such as yours as there used to be. Historically in this industry you had a large number who got to those kinds of positions who had civil engineering degrees or if they weren't degreed at least they had grown up a lot in the MW&S work and they really

understood it. They enjoyed it and hence they supported it well. That's not to say anything negative about people of different backgrounds who have come in because we are more of a business now than we are an institution. So you have to get people of different walks of life and different business backgrounds in. Given that the case, it makes it a little harder for you to get support and understanding for what you do and what you are up against. So you have to be a good communicator. Be a good communicator with your own people. Show leadership. Be a good communicator with your bosses and to all of these others that you have to work with as a team cross functionally to make today's business successful.

Use the opportunity you have to communicate about what you are doing, what you need, and your successes and some of the things that you can see coming up that are going to have to be dealt with. Don't be standoffish. Get involved in these cross functional teams. They can help you a lot more. They take time and, yes, you would probably rather be out on the track where the action is. Take time to be a leader across departmental lines. It's important that you have the support and understanding of those groups.

I have a story to tell you as an example. You have probably worked for similar people that I am going to talk about in terms of support and a style of leadership. It's kind of amusing when you see the contrast of how some people would manage the things we are talking about in the past compared to today. When I was superintendent of the Rocky Mountain Division of Burlington Northern based at Missoula, Montana, the regional vice president and general manager was an old timer named J.L. Davies. He was a heck of a good trackman. When I first came up that was the first superintendents job that I had other than the terminal job. J.L. said, "I am going to tell you something kid. I am going to teach you track work. You forget about running trains. You have done that all your life, but now just forget it. Here's your program this year. You have these curves to relay. You have these ties to put in. You have this amount of out-of-face surfacing to do and so on down the list. I want you to understand something. I am a trackman and I am going to make one out of you. So don't let the trains get into the way of the gangs." (Laughter) Think about that. Now it's the other way around. He held us accountable for getting the track work done. He had an interesting leadership style in many other respects too.

Service is our business. That is what railroading is about. It's moving freight to meet customer expectations and from there to gain a profit as well. So that makes it tougher for you now to do the work. That's an understatement, as though you didn't know that before. People are less and less tolerant of disruption to the scheduled railroad that we are trying to become than they were in the past. Hence it makes it a lot tougher to get maintenance of way work done. Of course the machines are bigger and more complex. You need uninterrupted periods to get some work done. At the same time, people are less tolerant of slow orders and disruptions that come from break downs or something that causes the signal system to fail or anything at all that interrupts train flow. People are less tolerant. I think you need to demonstrate more and more examples of things that can be done to prolong the intervals between the need for programmed work. Get a strong railroad built up that is really a showcase piece of track including the structures and the bridges and the signal system. Get it built up and do more and more of the things that have been done in the last ten years that have been successful.

Buy premium rail so you don't have to relay the curves as often. Improve the fasteners so there is less maintenance required and less danger from the safety side also, but we are talking more about the service side here now. Improve rail lubrication practices and improve grinding practices so the rail will last longer and you don't have to come in as often to change it out and disrupt the operation. Of course we are talking about high density lines now where these kind of things are a problem.

Some of the new designs now in turnouts include the movable point frogs returning to spring frogs with better maintenance practices than in the past. The use of concrete ties where they are economical. Keep looking for more things like this so you can extend the periods between cycle or programmed maintenance.

At the same time we need to look further I think at practices which will get you on and off the track more easily. It's easy to say these things and it's another thing to do them, but since I am in a planning type job and away a little more from doing things I can afford to take a little risk and suggest a few things which may be a little unrealistic. If they are, we need to find better ones to achieve the same results that being less time required for outage for maintenance work.

An example, of course, might be some applications like the Union Pacific did this year of taking I believe the North Platte Subdivision out of service for six days and really going in there and getting the work done. Now how many places can you do that? I don't know. There it obviously worked from all indications but look for opportunities like that. You need to take the lead on this together with the transportation folks and the operating people. Others aren't going to see that as well where there is an opportunity to do it. That may be one example of something that can work elsewhere. There may be some places where it certainly can't work. I can think of many where it can't.

Getting close to home on Wisconsin Central this year at Neenah, Wisconsin, there was a relatively small flat yard, a really busy one that needed to have all the turnouts on the lead relaid with new material. Also the alignment was not the best on those tracks and the clearances weren't the best. Glen Kerbs, the vice president of engineering, said to go in there and get all of this done at one time and get out. So, the work was organized so it could be done on a 24-hour basis in, I believe, five days. They got it done and got out. There was disruption for five days but at least it's only for five days you are talking to the customers and having to change the locals around and the industry jobs that have to fit in. At least then you could tell the customers about it and reschedule some of the work as a result. People are more tolerant and in five days you are done. We shouldn't have to do any work on that lead other than normal adjustment and maintenance work to make the switches the standard for safety for operation.

Some of you know I have made trips oversees. It's a totally different operation over there. Some of the things may in time make some sense. One time I rode the so-called bullet trains in Japan and noticed that they had light plants that were cantilevered over the gang so they got rid of the shadows during night work. They were out doing basic maintenance work with hand-held tampers and wrenches and whatever. Maybe there is an opportunity for those kind of things someplace but not for just the idea that we work nights and have to pay the overtime and look for a new union contract, but simply where it fits the service delivery better. Things like that need to be looked at.

I know there was a movement a few years ago to get some small machines that could spot ties in which we could get on and off the track easily. If you had an hour's work you could still work and get a few ties in. This is just maybe. In some areas you are going to have to go back to the really historic practice of having an allotment of section ties instead of these big out-of-face programs of 800 to 1,000 per mile. Maybe we are going to have to go to spotting in ties with these small machines, have a big enough machine and the work organized so the cost per tie installed isn't any higher than it is with the big production gangs that are so well run today compared to what they used to be.

So, things like this which probably are more sensible than what I am suggesting have to be part of your leadership role in order to better steer the organization towards service delivery which can be less disruptive and keep the reliability up that the customers are demanding so hard. We have a lot of business today. But next time we have some downturn in the economy, those who perform the best on service delivery are going to have the best financial results. You can't count on being as busy as we are all the time. So we have to have our operation or our service lined up so it is competitive in the lean times. Otherwise you can really get hit.

Well, this whole issue of capacity and being busy and having some lines where we are having trouble getting the trains on the road simply is really a nice problem to have. It's a heck of a lot better than it was for a long time around here where you had bankruptcies and huge

amounts of derailments from poorly maintained track and equipment. We have overcome all of those things. This is a very strong industry now. It has a lot of pride and respect from the public and respect from the investors. The customers respect us, too. They want more, but they do respect us. We have a really good, strong, powerful, well-performing business; as good as most anyone can find in American industry. A lot of that is due to the kinds of practices to get track work done at lower costs with better materials that people such as are in this room have pioneered and driven.

But you have to do more of this. Keep looking for better ways to do it especially focussed on this area of service with less disruption. I don't mean that as a criticism. I mean we have to do track work. Of course we have to do it. All I am saying is let's look for ideas that we can then suggest to the transportation people and the service design people and to the marketing people and say here's a better way to get this work done so you can have more time to get those trains over the road and keep the door-to-door dock-to-dock service on time for what the customer wants.

So you have accomplished a lot. You ought to take a lot of pride in it. Don't let anybody tell you that you aren't doing a heck of a fine service to your internal customers, your transportation department, and your marketing department.

With that, I am going to close. I wish you continued success in what appears to be a fine conference from the topics on the agenda. I also certainly wish you a safe trip home. I appreciate the chance to be here with you. Thank you. (Applause)

President Koff: Thank you, Mr. Currie. I did leave one important thing out and I want to come back to it. That is if you noticed on your conference survey form, John Cunningham appeared on this. John is home sick with what we think is pneumonia. We found out on short notice and it is due to some friendships that I have over on Wisconsin Central that Mr. Currie agreed to ride to my rescue by agreeing to come down and share some words. I really do appreciate your thoughtfulness in coming down and the thoughtfulness of your remarks shared here today.

With that, I have another gentleman who is not a stranger to our group and that's Gary Wolf. Gary has been with us at a couple of our gatherings and I have had the pleasure of seeing him at a couple of his symposiums on derailment investigations.

You don't say this often, but I am a Gary Wolf fan. I really enjoy hearing him speak. He has a lot of wisdom on a lot of issues. Whenever I am around him I learn something new.

Gary, as many of you know, is with Rail Sciences, Inc. He is the founder of that group and serves as its president. He received a Bachelor of Science degree in electrical engineering from Ohio University in 1971 and a Master's degree in science and industrial management from Georgia Tech in 1973. He began his railroad career in 1970 with the Southern Railway as a student mechanical engineer. From 1973 to 1976 he worked in a variety of mechanically related projects in the industrial engineering group.

In 1976 he began working with the new track train dynamic simulating model as a senior analyst. In 1987, Gary was promoted to manager at Norfolk Southern's operating research department. Following that, he left Norfolk Southern to form Rail Sciences, Inc.

He is with us today to talk about rail grinding, lubrication, and lateral stability; a practical approach. Would you please join me in welcoming Gary to our conference. (Applause)

RAIL GRINDING, RAIL LUBRICANTS, LATERAL STABILITY: A PRACTICAL APPROACH

Gary Wolf

President
Rail Sciences, Inc.

Very nice words, Ken, and thank you for that introduction. I come to you today to talk about a subject that is certainly near and dear to my heart and that is the three titles to this presentation. I guess the title is not as indicative as what Ken said, as I am going to talk not only about lateral rail restraints or lateral stability in the sense of truck buckling, but stability of the track in terms of its fastening and lateral restraint as well as these other two topics, rail grinding and rail lubrication.

Now, let me ask a question before we get into this too deep. How many of you in the audience have heard or read some of the articles in the last couple of years about the topic of rail grinding or I might even add the somewhat controversial topics of rail grinding and rail lubrication? Who has seen any articles relating to this stuff? That's great. Almost 100 percent I think. So it is a very relevant topic today. It's a very timely topic. I might add a follow-up question. How many of you fully understand all the theories and articles you read about rail grinding and rail lubrication? Not too many hands this time. There are probably a lot of good reasons for it. Some of the things that we have learned about rail grinding and lubrication and the interaction of those two things are sometimes counter intuitive.

Earl Currie just mentioned in his speech some of the developments in rail grinding and rail lubrication and their importance to maintaining good track structure. I am certainly here to say that I think both of them are very important. But it's like a lot of things in life: A little bit is good. Too much can be bad. That is true with both lubrication and rail grinding. We have to do it properly. We have to understand how to do it and what the results are or ramifications of our actions are.

When it comes to rail restraint I don't think you can say that too much is not too good because obviously the better your rail is restrained the better off you are going to be.

Now, where do all these things come together? Why are we talking about them? What is the end result? Well, as you are going to see in my presentation, the end result is going to be that combination of poor grinding practices and maybe lack of rail lubrication or lack of rail restraint. We ultimately end up with sometimes a very harmful result and that is a derailment. If not derailment we certainly are putting excessive lateral forces into our track structure that we don't need to be doing. This ultimately costs us more dollars to maintain that track structure. So any way you cut it, you don't want that end result. You certainly don't want derailments and you certainly want to minimize the lateral loads that are going into the track structure because that is deteriorating tie fastener condition. It is wearing out your rail and obviously those are very expensive assets to replace and/or maintain. It is important, as you can see, to minimize the intersection of these forces so that we don't either derail or have it cost us too much money.

Here's the typical result me might see from adverse combinations of lateral track forces. This is a fairly common type derailment called a rail rollover derailment. This was a low rail roll where you can see that the low rail started to cant up here with the car entering into a curve. That is a very common type derailment. It results from combinations of lack of lubrication or perhaps some aspect of grinding. Certainly there are mechanical factors involved as well.

Some of you may brighten up when I say mechanical factors being involved, but it is true. I am not going to stress that so much today. I will touch upon some of the mechanical factors, but you are going to have to come to one or the other mechanical sessions to hear about those in detail if that's what you want to hear about. I am going to stick mostly today to the track factors and what you can do to better manage these kinds of complex intersections of grinding lubrication and rail restraints.

It may not be as tragic as that derailment, but here we have another typical derailment. This is one that as roadmasters you may be playing with. It's the infamous wide gauge derailment. They spread the gauge and they are always coming back with what used to be T101 or whatever the cost code was of wide gauge. This was obviously not too bad of a derailment here, but we did spread the gauge. You may be faced with that type of derailment which, again, can be a result of these complex interacting forces between the wheel and the rail. It's not always due to weak tie restraints.

To show you that it's not always a factor of rail restraint or poor track condition although this isn't the best tie condition here, this is kind of a curious thing that happened. We were testing some cars and we were shimming side bearings on the cars to see the effect of tight side bearings out on a piece of track being instrumented. We had this particular car which is hardly visible in and out of this track a dozen times bringing it to the mechanical one spot where we were jacking in and putting side bearings in. Then on the final test where we shimmed the side a tight condition and pulled the car out, it spread the gauge.

Now, if nobody knew we had been there screwing with the side bearings, who do you think would have been blamed for that derailment? You guys probably. It would have been a wide gauge derailment, poor tie condition, et cetera. But we were there and we were messing with the side bearings and we knew we shimmed them tight. As soon as we had them shimmed tight, the gauge slipped. What causes that? Why can that car go through the curve ten times and then the eleventh time it results in a spread gauge? These are some of the complex factors that you have to deal with in this whole equation of rail rollover and wide gauge and wide gauge type derailments.

Now, some of the physical evidence that you will see at the side of the wide gauge and/or rail rollover derailment are these. You have probably been there when it comes to many of these. The first thing is wheel marks in the web of the rail where the wheel drops in. We may see spikes pulled up on the gauge side certainly or raised spikes or high spikes prior to the point of derailment.

This is another one that is a common symptom of these rail rollover type derailments where leading into a curve perhaps we see a whole series of raised spikes particularly the rail restraint spikes on the inside gauge. There are a few other factors, such as the base of rail may be laying on top of rail heads where it's pulled up and fallen back down on top of the spike heads. That is common in a rail roll type derailment.

We may have either high or low rail rolled over or both. Very commonly, it's both rails that are found rolled over. Why is that? Those people always think it's the high rail in a curve that has to restrain these high lateral curving forces. But it turns out that you have an equal and opposite force on the low rail tending to shove it out. Because of the adverse geometry of low rail contact where the flange is pulled way off of the low rail, it actually is easier to roll over the low rail in curves than it was the high rail. That is an important consideration for those of you charged with maintaining curves and things. Your low rail has to be as well spiked and fastened as the high rail because those forces are there.

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Symptoms of Rail Rollover/Gage Spreading
Track Conditions at Site

- Wood ties with cut spikes
- Dry rail, high or low
- Recent rail grinding
- Differential tie plate cutting
- Heavy gage face wear on high rail
- Spike killed ties

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Symptoms of Rail Rollover/Gage Spreading
Operational Factors and Car Conditions

- Low speed/Under balance speed
- Heavy bulk commodity/Doublestack cars
- Hollow worn wheels
- Tight side bearings
- Heavy truck wear

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Myth vs Reality of Rail Rollover

Myth: Most Rollover/Gage Spreading Derailments are caused by an engineer applying too much Dynamic Brake or Heavy Throttle

Reality: Most Rollover/Gage Spreading occurs under low Drawbar Force Conditions (Draft or Buff)

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Myth vs Reality of Rail Rollover II

Myth: Most Rollover/Gage Spreading Derailments are identified as "Wide Gage"

Reality: Rail Rollover is a complex phenomenon involving the timely interaction of many causative factors

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What Causes Rail to Roll?

Six Things Must Occur...

1) Requires 2-3 "Bad Actor" Trucks in a Row
2) Loss of Wheelset Steering
3) High Truck Turning Moment (Resistance to Turning)
4) Low Truck Warp Restraint
5) High Overturning Moment on Rail
6) Poor Rail Restraint

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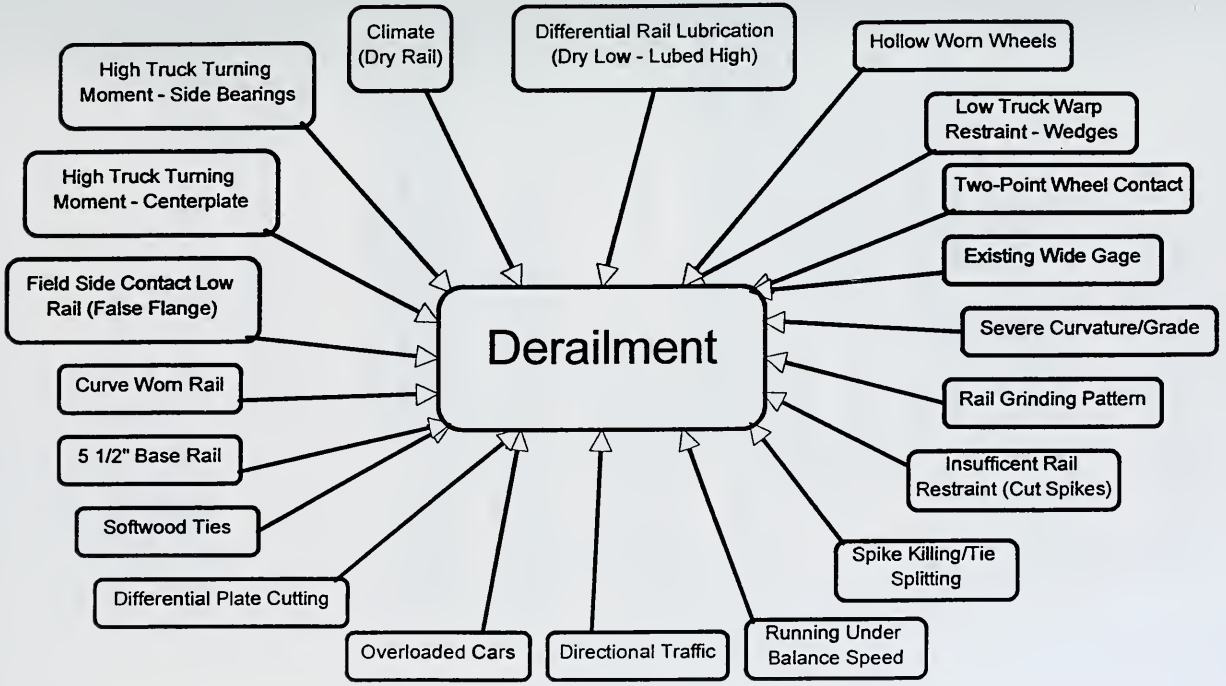
Rail Rollover - Contributing Factors



the low rail in curves than it was the high rail. That is an important consideration for those of you charged with maintaining curves and things. Your low rail has to be as well spiked and fastened as the high rail because those forces are there.

Often the first derailed cars are upright between the gauge and often we find that these rail rollover type derailments are associated with dry climate. This really came to light very suddenly and very obviously about six or seven years ago when we did some of the research on the double-stack derailment phenomenon. Maybe some of you remember those days when the 125-ton double stacks were first introduced into this country in the late 1980s. We had a whole series of rollover derailments. All of them that we recorded were west of the Mississippi River. All of them seemed to occur both in times of very dry climate and/or in the arid regions such as some of the deserts like the Mojave and in Texas and up in the California area where it's extremely dry in the fall months. So we saw a very decided relationship between rail rollover and dry climate conditions. In fact, the Norfolk Southern guys on the committee wondered what the hell happens to these cars when they cross the river. They just didn't derail on NS or CSX or Conrail; they were all happening out on the western roads. But there is this complex relationship. Again, this gets back to the rail lubrication issues. I want you to be aware of that because we are already into a very dry climate period now particularly in the southwest. You will see just how important it is to get good lubrication down on the track in those areas.

Here's the familiar slash mark that you will see down the web of a rail from a rollover rail. The wheels drop in and they will start to ride down the web of the rail and ultimately if it's a low rail, it rolls. Ultimately they drop in on the high side and that causes the high side to pull back.

Here's the common looking symptom you will see. The spikes are raised. They have been pulled up. The rail is disengaged from the spike head and have started to cant. You can also notice wheel drop marks on the low rail in this case where wheels are dropping in as they are derailing. These are some of the symptoms that you might see approaching a typical rollover type derailment.

Coming right at you here is a high rail rollover. Again, you will see the rail pulled up, spike heads up, and then wheels dropping in on the low side. Ultimately it may spread that low side out and cause it to spread out as well.

Some of the symptoms of the track conditions that we will find at a site with rail rollover gauge spreading type derailments are wood ties with cut spikes. It is just a fact of life. I personally have not been involved with rail rollover with an elastic type rail fastening system. You can take your pick; there's Pandrol, McKay, Safelok. Those systems seem to do a much better job at restraining the rail and preventing these types of accidents from happening. I think we have reached the ultimate limit for our cut spikes with the modern loads that we are putting into our track structures. You can run all the compilations and numbers and you will see that the type of lateral forces that loaded 286,000 cars can put into the track structure are putting the spike right about at its elastic limit to where it can restrain those forces day in and day out. If you are just running an occasional train like that, you can get by with it. However, if you are in heavy unit train service, it's pretty clear that the cut spike system is really being stressed to its ultimate limit.

As a consequence almost all these types of rail rollovers or gauge spreading derailments are occurring on the cut spike track.

We had one happen about six or seven years ago on a western road where a train came through a series of S curves. The first curve happened to be Pandrol clips on wood ties. I am not advertising Pandrol but it is just what happened to be there. There are many out there that will do a good job. In this case, the first curve was Pandrol clips. The second curve was cut spikes. Guess which one the rail rolled in? It was the cut spikes. It was the same car that came through both curves, but it picked the cut spike track to cause the rollover phenomenon.

Low Rail vs High Rail Rollover

In most cases, the low rail is the first to roll outward during curving. The high rail rolls as a secondary reaction to wheelset drop.

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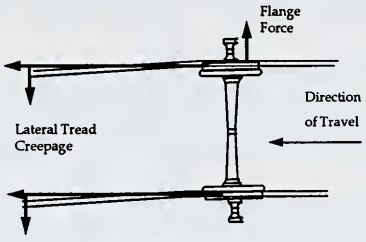
How do we develop lateral forces toward the inside of a curve?



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Poor Truck Curving Performance Results In:

- Derailment
- Gage Widening
- Excessive Rail Wear
- High Contact Stresses (Shelling & Spalling)
- Fastener Deterioration
- Accelerated Crosstie Plate Cutting

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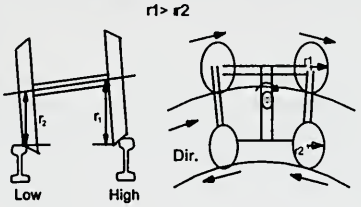
Loss of Longitudinal Steering Moment

- Must develop larger radius on High Rail vs. Low Rail



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Factors That Affect Truck Curving Performance

- Car Factors
  - Wheel Profile
  - Centerplate Lubrication
  - Truck Warp Restraint (Friction Wedges)
  - Truck Turning Moments
- Track Factors
  - Rail Profile
  - Rail Lubrication

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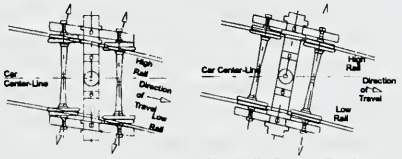
Low Truck Warp Restraint

- Ideally, a truck should remain "Square" during curving to allow radial alignment of wheelsets with curve



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Again, we will see dry rail both on the high or low side. This gets back to the lubrication and climatic factors. We may see evidence of recent rail grinding. Again, that's why I am here to talk to you about this because recent rail grinding has shown up in a number of these types of rollover derailments. I am not saying grinding is bad, but, again, the message is we have to control it and manage it properly. We will find out what I am getting at concerning rail grinding.

This fourth one is one that I think a lot of people don't understand the significance of. It's the differential tie plate cutting. What I am saying there is you will notice it on a curve where the field side of the tie plate tends to cut deeper into the tie than the gauge side. That is a natural phenomenon given the way the forces are put onto the tie plate. It's not so bad except when it gets excessive. It can cant the rail out.

Regarding rail that has almost reached the end of its effective service life or heavy gauge face wear on the high rail, some would say the wheels are still rolling on it. But as you wear away that gauge face you also start predisposing incrementally the possibility that the rail will start to roll over. The more gauge face that you lose, the vectors just start going against you in terms of their propensity to roll the rail. It will show up at the site of these types of derailments; that is, ties are just worn out. There are split ties, rotted ties, and ties that have been respiked five or ten times in gauging operations. There are ties that haven't been replugged properly, et cetera.

Here's an example of some spike killed ties. The ties are split. These splits run right up into the base of the rail and oftentimes the spikes in those areas just don't do a good job of holding the rail.

This is the field side. You can barely see it but the gauge corners are the same way. We talk about rail profile that may have reached the end of its life. As you start to wear the gauge corners away you start moving the loading point over into this area and now your vectors are coming out closer to the field side. The more you move that load vector toward the field side, the more that rail wants to roll over.

Again, you may have service life remaining and you may not be experiencing a lot of fatigue defects yet, but rail that is heavily gauge corner worn is also rail that is more prone to this phenomenon.

Here is a good example of differential plate cutting. It shows how your field side has cut in quite deeply. Your gauge side, however, is still resting pretty proud on the tie. Some might say that tie isn't too heavily plate cut, but it's differentially plate cut and that's the key. That is what sets that rail up and cants it and allows it to roll much easier.

What are some of the operational conditions? I am sure you are all curious about what else we can blame this on. Well, some of the things you might see from the operational and car condition side are low speed or under balance speed. As you know, on some of our track in our country we have to balance it for maybe an occasional passenger train or maybe an occasional pig train that comes through there. However, our bulk commodity trains may be running considerably under the balance speed for that curve. When we do that we put excess stress on the low rail. Those of you maintaining curves know that. You start to see spalling. You start to see heavy cutting on the low rail if trains are running consistently under balance speed. If that's the case, I suggest you work with transportation and maybe get the speed for that curve lowered to where you can then reduce some of that elevation to keep those forces in balance.

We find heavy bulk commodity cars particularly double-stack cars are some of the real bad actors that cause these problems. Those of you dealing with heavy 286,000 coal and grain now and the big stack cars know what I am talking about. Your rail is getting beaten to death out there with these heavier loads. Consequently we have to pay more attention to what we are doing.

Next is the issue of hollow worn wheels. Now, this is one that you folks can't control too well. Unfortunately, even the mechanical folks can't control hollow worn wheels too much

because there is very little that the AAR rules say about hollow worn wheels. However, time and again we see hollow worn wheels show up at the site of these rail rollover derailments. So we know that they have a deleterious effect on the track structure. A hollow worn wheel will place the vertical loads way to the field side of your rail, either high or low side, and again set up the conditions for rollover.

We find tight side bearings on the cars and just generally heavy truck wear where a truck is just worn out. It has excessive wedge rise or friction casting rise. It has heavy center plate wear. All these conditions cause the truck to be a poor curving truck.

Here is a good example of a hollow worn wheel. If you put the straight edge across it you will see the wheel is heavy dished out. What that does especially on the low side is you will be loading the rail way up on the outer edge of the wheel. It's going to contact the far field side of your low rail in a curve. That is just a bad situation which I will get to in a little bit.

These are the tight side bearings I am talking about. These big, orange rubber blocks are called Stuckey constant contact side bearings. We see these types of side bearings show up a lot at these rail rollover derailments. When we do, we generally find them to be compressed too tightly. It is something that you would want to be sure that the mechanical fellows and gals are getting these cars on the rip track and measuring the side bearing clearance if that is the car that spreads the gauge or rolls the rail. We do notice a trend or relationship between these types of bearings and high curving forces at times.

These are steel rockers if you are familiar at all with side bearings. These are rubber blocks. There is supposed to be a clearance in there but they are riding right on the steel rockers which is a bad situation.

Let's talk about some myths versus realities of rail rollover. I think a lot of people and certainly myself included when I first started studying derailments back in the 1970's kind of felt that if you had a rail rollover derailment it was caused by too much dynamic brake or something that the engineer did to cause high compressive forces in the train which translated to a lateral load. The reality, though, is that most of these rollover or gauge spreading derailments occur under positions in the train where there are low draw bar forces both bump or draft. It's almost as if they prefer that the forces be quite low on the cars because if they have high forces bump or draft we tend to push the wheels around and get them in better alignment sometimes. We see that it's often not the high draw bar forces that cause to you roll the rail, but it's just a combination of low forces in the train actually.

Most of these derailments are identified in the statistics as wide gauge derailments. Many of you probably get sick of hearing that term. The reality is that rail rollover is a complex phenomenon involving the timely interaction of many positive factors. When I say timely I mean that you have to have all the stuff coming together at the right space at the right time for this to happen. Take one of the factors out of the soup and it doesn't happen. You lubricate the rail and it doesn't happen. You fix the side bearing clearance and it doesn't happen. You raise the speed ten miles an hour and it doesn't happen. However if all these factors come together at the same point in time, you will have a derailment.

I am sure some of you out there are faced with this perplexing question and ask why did this thing derail today? That track has been out there for ten years like that. Why today? Why at 9:00 a.m. this morning? Well, again, it's the timely interaction of all of the factors.

I think there is a probabilistic sense to this whole equation of getting these whole factors combined at the right space in time. However, the good news is by knowing what these factors are and controlling them properly you can eliminate the risk factors. Because what we are doing here is managing risk. We know lubrication is in it. We know rail grinding is in it. We know rail spiking and restraints are in the equation. The question is how do you manage those combination factors and keep the risk as low as possible.

Rail Sciences Revenue Service Wayside Testing

- 4 and 12 Degree Curves
- 115# and 136# Rail
- Bulk Commodity and Mixed Freights
- Heavy and Moderate Grades
- Wood Tie; Cut spikes

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Trackside Instrumentation

- Lateral/Vertical Strain Gages (High and Low Rail)
- Two Cribs - Full Body of Curve and Spiral
- Analog and Digital Data Acquisition (1000 Hz. Sample Rate)
- Rail Base and Head Displacement

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Test Variables

- High & Low Rail Lubrication Conditions
- High & Low Rail Profiles

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Rail Lubrication

- High Rail Head & Gage Face
- Low Rail Head
- Measured with Tribometer
- Lubrication Applied Manually and with Hy-Rail Mounted Equipment
- Wayside Lubricators Turned Off
- Locomotive Flange Lubricators Turned Off

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Rail Lubrication Conditions

- Favorable
  - ➢ Lubed Low Rail
  - ➢ Dry High Rail Head
  - ➢ Lubed High Rail Gage Face
- Unfavorable
  - ➢ Dry Low Rail
  - ➢ Lubed High Rail Head
  - ➢ Lubed High Rail Gage Face

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Well, this shows the contributing factors that all relate to this phenomenon called rail rollover or gauge spreading. There is a bunch of stuff involved. Some of it is track related and some of it is mechanical and some of it is operational related. There are things like climate which I mentioned. Other factors included are truck turning moments, center plate conditions, false wheel flanges, curve worn rail, narrow base rail of 5 1/2 inches, overloaded cars, directional traffic, spike killing, pre-existing wide gauge, two point wheel contact, hollow worn wheels, and differential rail lubrication conditions. These are just some of factors that are contributory to this phenomenon.

Today I am going to focus on those three areas that Ken Koff mentioned at the outset of my talk and that is lubrication issues, grinding issues, and rail restraint issues because those are the three that you folks can probably control or maintain the best of all of these. Climate is somewhat out of our hands. It's going to be dry or wet. We don't have a lot of control over that. But we can control the effect of the climate by proper management of lubrication.

What causes rail to roll? We have been talking around the topic. There are six factors that we must have come together in a probabilistic sense. First of all, we have to have two or three or four bad axle trucks in a row. One bad truck coming through a curve that is acting up, not curving, is stiff, does not roll rail. It might open the gauge up a bit, but the gauge will snap right back due to the torsional restraint of the rail. However, it's clear that when you get two or three of these in a row that's the problem. This is where the probability factor comes in again. If you just switch those box cars around and have the green one behind the red one you probably wouldn't have had the rail rolling. But if you get two or three of these trucks that don't like to curve too well on the road then you get these forces developing.

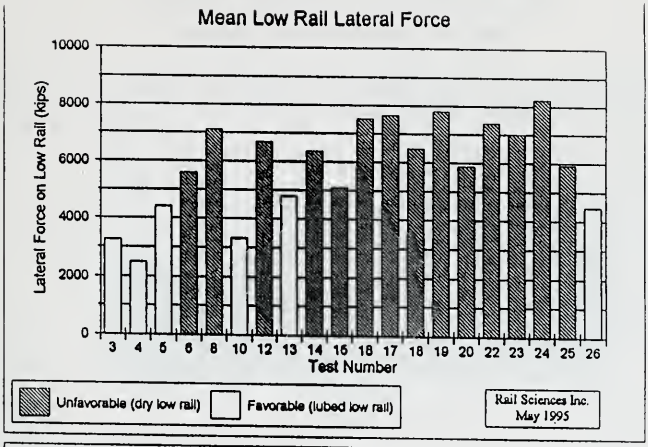
It requires a loss of wheel set steering. How do we get that? Well, wheel set steering is an issue where it takes two to tango. You have to have the right wheel profile and you have to have the right track grinding profile. Again, it comes back to rail grinding. Rail grinding is something you can manage in this room and how you profile that rail to try to improve wheel set steering. The fact is there isn't a whole lot we can do with wheels because if you are on the West Coast and they are coming across the Mississippi River bridge from the East Coast you are going to have to accept those wheels at St. Louis and Memphis and New Orleans and Chicago and other places. Whether you like it or not, if they are hollowed out or if they have thin flanges or whatever. If they are not condemnable you are going to be running those wheels. The key is as a track department to manage a rail profile and try to improve the odds that those wheels will steer even though they are not the best.

High truck turning moment is a resistance to turning or stiff truck conditions. That is not anything that we in this room can deal with. That's the mechanical side of the house. When I talk to them I certainly stress this factor. They have to lubricate their center plates so that these trucks turn properly. We know that a tight center plate or stiff center plate is a prime causative issue.

Low truck warp restraint, again, is a mechanical factor and there's not anything we can do about it here.

High overturning moment on the rail is a situation where we come back to an interactive factor. We know some of these hollow wheels are going to put a high overturning moment on the head of the rail. We also know by properly profiling the rail we can perhaps mitigate some of that and move those forces back. By eliminating differential plate cutting we can move those forces back to the center of the rail. Perhaps we can then get away from these high overturning moments.

Lastly, we will deal with poor rail restraint. As I said a few minutes ago, it seems that every one of these has a factor of rail restraint. We go out to the scene and we find spike killed ties, heavy plate cutting, split ties, web ties, missing spikes, raised spikes, and those kinds of things.


Mean Low Rail Lateral Force
Lateral Force on Low Rail (kips)
10000
8000
6000
4000
2000
0
3 4 5 6 8 10 12 13 14 15 16 17 18 19 20 22 23 24 25 26
Test Number
Unfavorable (dry low rail)
Favorable (lubed low rail)
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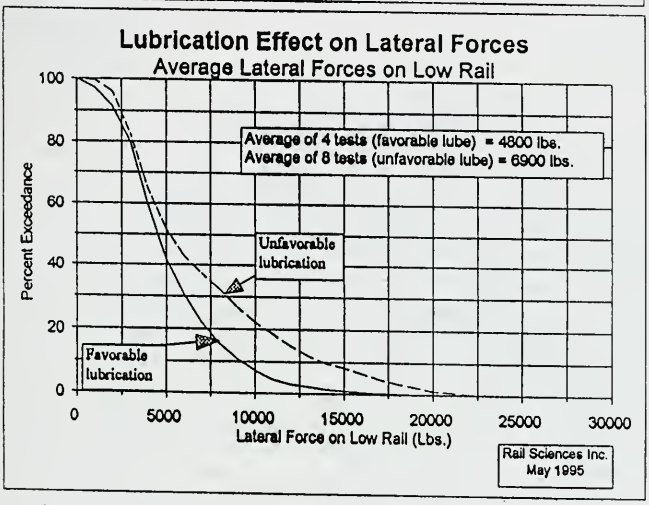
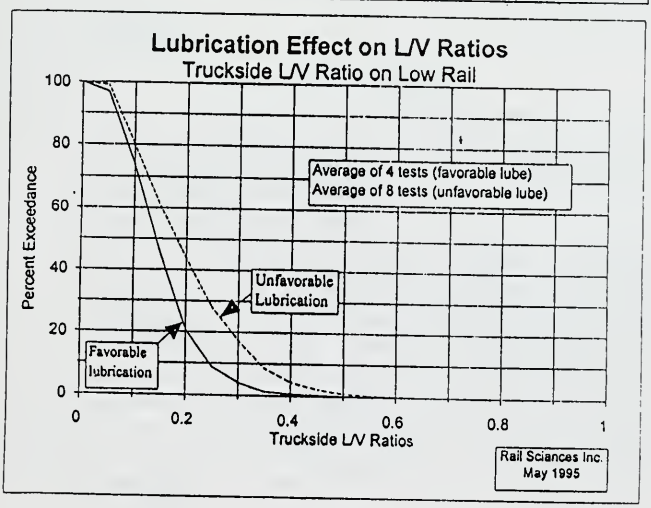
May 1995


Lubrication Effect on Lateral Forces
Average Lateral Forces on Low Rail
Percent Exceedance
100
80
60
40
20
0
Average of 4 tests (favorable lube) = 4800 lbs.
Average of 8 tests (unfavorable lube) = 6900 lbs.
Unfavorable lubrication
Favorable lubrication
0
5000
10000
15000
20000
25000
30000
Lateral Force on Low Rail (Lbs.)
Rail Sciences Inc.
May 1995


Lubrication Effect on L/V Ratios
Truckside L/V Ratio on Low Rail
Percent Exceedance
100
80
60
40
20
0
Average of 4 tests (favorable lube)
Average of 8 tests (unfavorable lube)
Unfavorable Lubrication
Favorable lubrication
0
0.2
0.4
0.6
0.8
1
Truckside L/V Ratios
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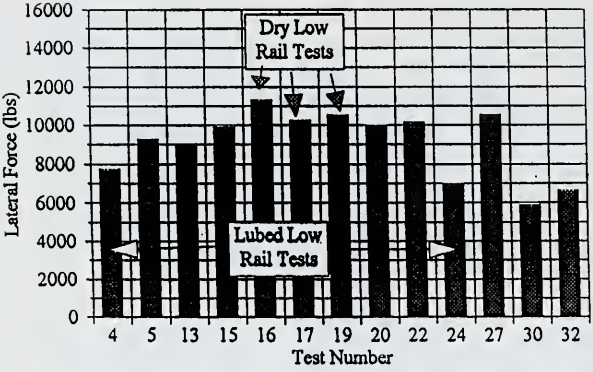
May 1995

Mean Lateral Forces (Low Rail)
Loaded Southbound Trains



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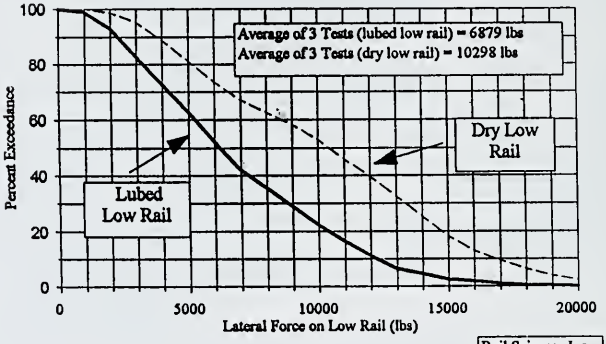
Lateral Forces - All Axles
Lubrication Effect on Lateral Forces



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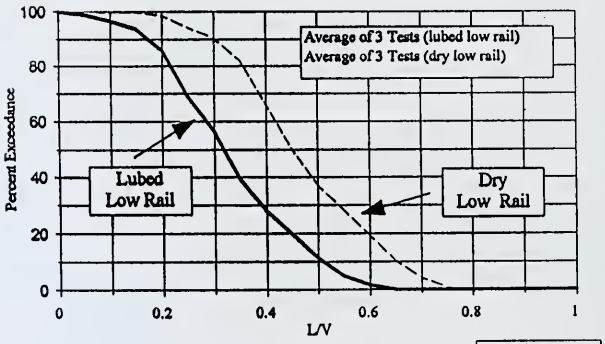
May 1995

Truckside L/V Ratios
Lubrication Effect on Truckside L/V's



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May 1995.

So these are the six factors that have to come together. We are going to focus on the turning moment on the rail due to profile grinding, the rail restraint and the steering due to good lubrication and good rail profile.

Now let's focus on low rail versus high rail rollover. In most cases, as I said, the low rail was the first one to roll in these types of derailments. I think as I develop the presentation you will begin to understand why. It's because of the way the forces are put on the low rail. The wheels are pulled away from the low rail and you engage those false wheel flanges on those hollow wheels. They are running way on the field side of your low rail. It may be spalling it. I have seen some curves where it is actually grooved out there on the low side or the field side of the low rail. You actually can run your thumb across it and feel a bit of a groove developing. You are placing those forces way towards the field side where they can be a bigger factor in causing that rail to cant or roll.

The high rail often rolls as a secondary reaction to wheel set drop. That is something I would caution you to look at very closely if you have had the unfortunate need to go to a rail rollover derailment and both rails are spread. Take a hard look and see if there is not evidence where the low rail had started to lift or cant upwards for five or ten ties in a row where the spikes were raised. If that low rail starts to cant, it will allow the wheel to drop in on the high side. Then it just peels both rails back perhaps or just peels the high side back.

Now, we can develop lateral forces pushing towards the inside of the low rail of the curve. How do we do that? These are typically called creep forces in that the wheel set must creep continually as it goes around that curve. Think of it as pulling that wheel set on a chain and as you pull it, it is constantly moving towards the low side of the curve or it has to frictionally creep across the low rail and the high rail as it goes around that curve. We can get perfect steering or we can't generate enough of the radius differential above two or three degrees of curvature for that wheel set to roll freely. So it's going to slip or slide or creep sideways as it goes through the curve. That creeping to the low side is what causes these low rail type derailments or causes the forces to be developed against the low rail.

Now we must react that creep force with a high rail flanging force to keep everything in balance. You remember from your sophomore statics class that all equal and opposite type forces must remain in balance.

Now, I think this is repeating some of the obvious, but for those of you in the room I think this is an important picture. It not only tells you that we might get a derailment from these, but we will get gauge widening, excessive rail wear, high contact stresses that lead to shelling and spalling, fastener deterioration, and accelerated cross tie plate cutting with deterioration of the timber out there if we're dealing with a timber track. Even on concrete ties it can also lead to enhanced rail seat abrasion problems.

So the first one isn't very good because that gets everybody upset. But the next five or six in a row are things that affect you and your maintenance budget and the amount of time you must spend on your curve maintenance. So even if you are not experiencing derailments, it makes sense to manage this whole issue of lubrication and grinding and restraint so as to minimize the cost factors involved in those other five areas.

When we talk about loss of steering moment, what we try to do when we go around a curve if we are going around in this direction by virtue of wheel taper is we try to develop a larger radius on the outside rail than we do on the inside rail. That's why our wheels are tapered with a one and twenty taper across the track. Just think of a coffee cup that has a taper and roll it. It goes in a circle naturally. So if we can develop a larger radius on the high rail and a small radius on the low rail that wheel set will naturally try to curve itself. But if we do things to reverse that steering moment and get a bigger radius on the low rail than on the high rail, it's going to steer it right into the curve. In fact, we actually reverse those steering moments by poor rail grinding habits and/or poor lubrication habits. We can actually cause those steering moments to be reversed. It's only a one or two or three millimeter differential that we are talk-

ing about. It isn't a lot, but it's enough to ultimately steer that wheel set right into the high rail and cause gauge spreading.

Factors that affect the curving performance of a car are wheel profile, center plate lube, truck warp restraint, and the wedge of the truck turning moments. Again, those are not things that you folks can control too well, but you can certainly put a bug in the ear of your mechanical foreman out there that he better be checking these items after one of these derailments.

Regarding the track factors again, the other two are profile and lubrication. They have a tremendous effect on the ability to make the truck curve properly. Again, maybe we are not talking about a derailment but we are talking about dollars in terms of those poor curving trucks that you hear out there when you are doing a wayside inspection. When you hear a truck coming through screeching and throwing sparks and hollering and acting up, that truck is grinding away your rail. You all know rail is the biggest single asset that you have to buy each other so anything you can do to improve that is well worth it.

When we have low truck warp restraint, again, we are talking more mechanical factors here, but the truck tends to go into this warp or parallelogram mode. This is what is called a three piece truck. The truck is supposed to stay square as it goes through a curve. You might ask why don't those mechanical guys fix those trucks and keep them square? That is a good point and they are trying to do that, believe me. But, again, we come back to things that you fellows and ladies can do to make that truck remain square and hopefully get it around the curve without this adverse warping effect. I have already mentioned that it takes several bad trucks in a row to cause rail rollover or gauge spreading.

This is a very interesting chart from a test we ran recently. It is strip chart output. I think it's a truly amazing chart because it shows you what goes on out there when we have some of these bad combinational effects take place. What we have here are forces. These are individual lateral wheel set loads of each wheel. If you look at the pattern, the train is moving one way. This is a lead truck of a car, lead axle, trail axle, lead truck, and this is the truck center spacing and then we have the trailing truck, lead axle, and trail axle. Then coupled very closely behind we have the next car. There is the lead axle, trail axle of the lead truck, lead axle, trail axle of the trailing truck. So you get the picture. We are measuring every wheel that comes through a site. We are recording those lateral forces that those wheels are placing into the track structure. Just to orient you a bit, this is about 25,000 pounds or 25 kips. So this is about a 20,000 kip wheel load.

On the bottom chart we are measuring the displacement of a high rail. How much the head of that high rail flexes or cants out under these forces. We are looking at the relationship between a high force and the rail spreading or the canting of the rail. What we see with normal trucks or normal curving is under the lead truck of a car we will get a little bit of a displacement of the head, spikes are out there about 1/4 inch or 3/8 inch. Then it snaps right back between the truck center. The trail truck which is better behaving doesn't snap it out just as much. Then we have a warp lead truck that snaps it open pretty good. But it goes back to basically zero displacement. Then the trail truck snaps it out a bit on the lead truck. That is sort of what happens with the train going through your curve. That rail is moving outward, coming back, moving outward, coming back, and that sort of fatiguing thing is what is eating up your fasteners and your tie life, et cetera.

Now, let's look at what happened when we had a couple of these bad trucks in a row. We have a combination of a trail truck that is warped. It's producing high forces. We have a lead truck that is warped. It's producing very high forces. Then we have another trail truck that is warped considerably and another lead truck. That is four trucks in a row that are acting up and look how it holds that rail open and gets it open over half an inch, holds it there, and it doesn't snap back until it gets to this third car. Now if you had repeated that with maybe two more cars in a row, we might have opened that gauge up considerably and dropped it in. That's the affect of two or three of these bad trucks in a row.

Conclusions - Rail Lubrication

- Moderate Lubrication of Low Rail Head (f=0.3) Significantly Reduces Lateral Wheelset Forces
- Moderate Lubrication of Low Rail Significantly Reduces Percentage of Warped Trucks
- Rail Lubrication Must be Closely Controlled to Prevent Tractive Effort Problems

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Rail Profile Testing

- Effect of Conformal vs. 2-Point Contact
- High and Low Rail Profiles Altered
- Revenue Service Mixed Freights
- Profiles Measured by Laser and Mini-Prof
- Lubrication Varied

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Four Profiles Ground

- Pre-Grind - "Conformal" (New Rail)
- Grind #1 - Moderate 2-Point
- Grind #2 - Severe 2- Point
- Post Grind - Severe 2-Point with Field Relief on Low Rail

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Wheel/Rail Contact Geometry

Single Point Contact	Moderate Two-Point Contact	Severe Two-Point Contact

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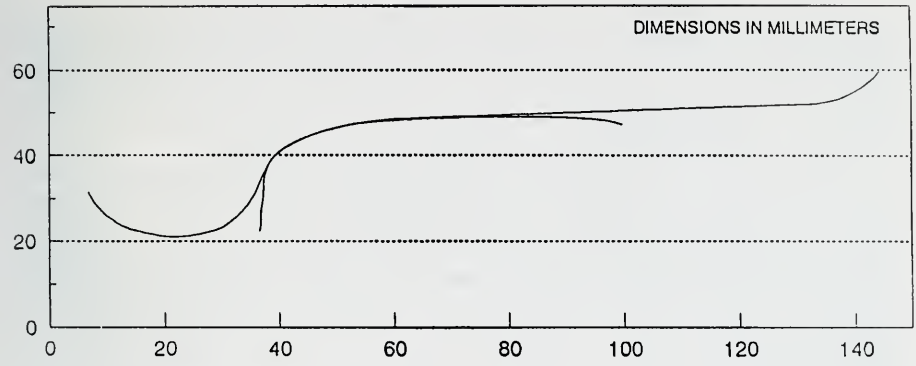
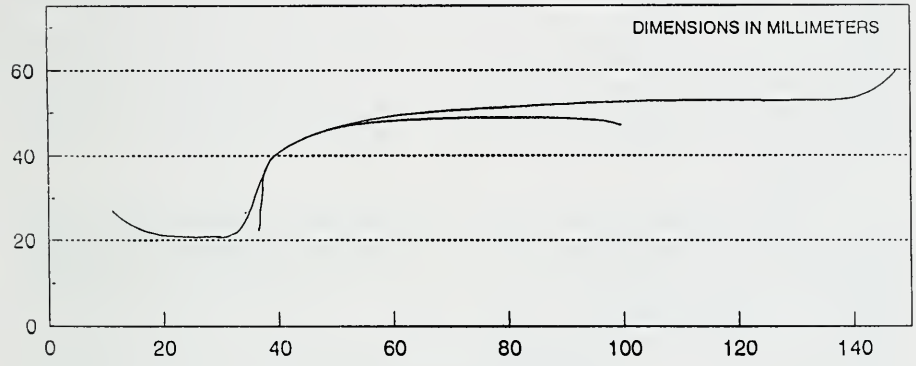
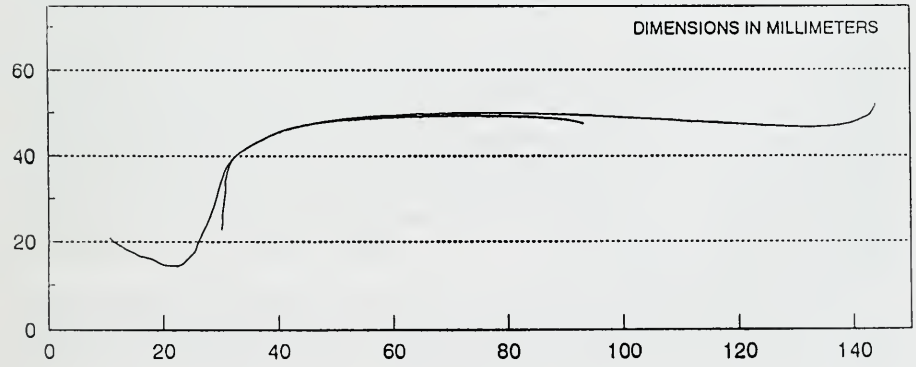
New AAR1B Wheel on Pre-Grind High Rail



Average Worn Wheel on Pre-Grind High Rail



Severely Hollow Wheel on Pre-Grind High Rail



As you can see the normal effect of a poor steering lead truck and a better steering curve truck doesn't really do much. That's normal. It's always the lead truck that screws up. Just keep that in mind at your next derailment. When you spread the gauge, the lead truck is the one that typically has a hard time getting through the curve. The trail truck just comes along for the ride so to speak. It doesn't normally produce high forces. However, when you have one that does in conjunction with a bad lead truck, that is what opens up your gauge.

The result of these warped trucks can be seen sometimes as the scuffing marks on the rail. Sometimes you have a curve where you have seen little marks usually about the size of a dime in the form of little lateral scratching marks. If you see those marks in a curve, it should tell you that you are not getting good wheel set steering performance. You also see those marks on a wheel. Those lateral scuff marks will also appear on the wheel. What that is is those high forces flex that rail out and then the rail snaps back. That snapping back action slides across the wheel set and results in those lateral scratches. That should be a telltale sign for those of you in the audience charged with maintaining track that we have a problem when you start seeing those especially on the rail.

I want to bring you up to date on some revenue service testing that we have done. I know I have been talking a little bit about theory and showing some diagrams and things, but let's get down to the nitty gritty and inform you about some of the tests we have run to show the effects of two things: different rail grinding profiles and the affects of different lubrication patterns on curving performance.

These were a series of tests done on both 4 and 12 degree curves. We had both 115 and 136 pound rail involved. We had both commodity cars as well as mixed freights. We had heavy and moderate grades represented and we had wood tie cut spike type track. Some of these tests were performed on concrete track. We have done some tests just very recently on concrete track and, again, the rail displacement was almost negligible on the concrete track with the elastic fasteners.

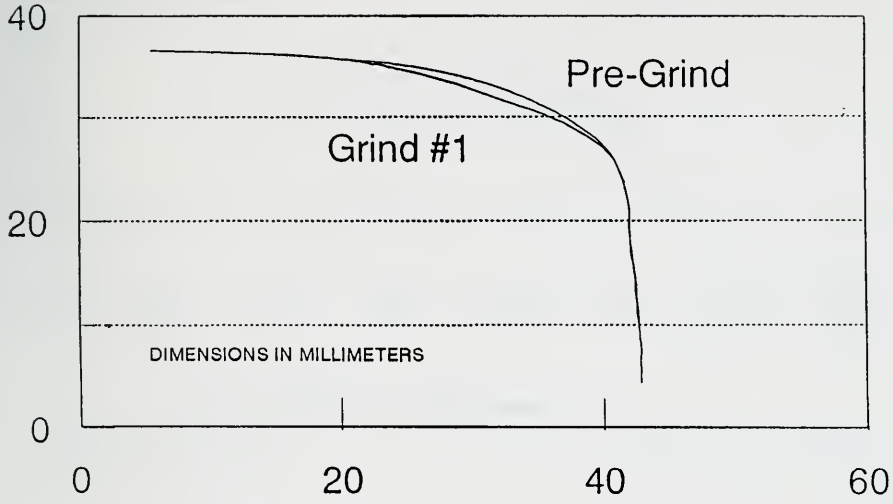
So we have a whole series of testing results which represent a wide variety of curve conditions, rail types, et cetera. What we had as far as instrumentation is the lateral/vertical string gauges to measure the high and low rail lateral and vertical forces. We had two cribs, one from the full body of the curve and one in the spiral. We used both analog and digital. We also measured rail base and head displacement. That is how much the rail is flexing outward and how much it is spreading.

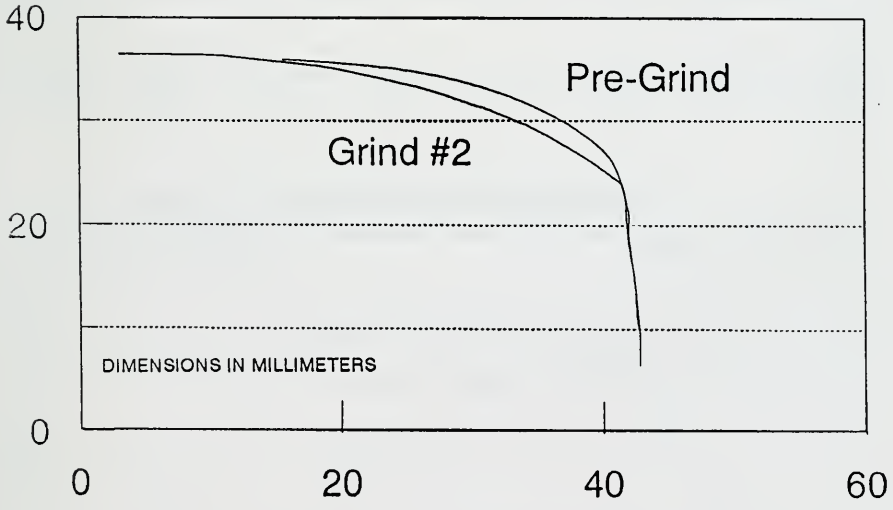
The strain gauge allows you to measure both the vertical load put on the rail from the wheel. We can measure the lateral pressure put against the rail from the wheels as well. We then just supply the data on the computer.

What were the test variables or independent variables if you will? There were both the high and low rail lubrication conditions and the high and low rail wheel profiles. That gets back to what we started off talking about. It's the management of those two functions.

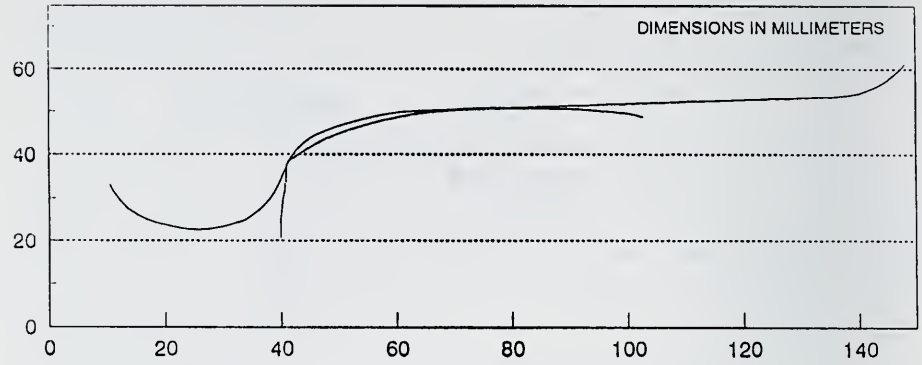
Regarding rail lubrication, some of the parameters we dealt with were the high rail head and gauge face was monitored, too. On the low rail we just worried about the head because we don't really contact the gauge corner of the low rail. It's mostly the head of the low rail that we are worried about. But on the high side of the curve, of course, it's that very important gauge face surface as well as the head of the high rail. We measured the friction coefficient with the tribometer which is a device to measure friction factors. The lubrication was applied both manually and with high rail mounted equipment. Before these tests, we turned off both the wayside lubricators that were nearby as well as any locomotive flange lubricators so as to minimize the interference from those factors. We were just trying to maintain a very stringent type of lubrication condition at the test curve.

This is a tribometer. They are pretty nasty to deal with. The tribometer are rather cantankerous devices but when they work they look like a little vacuum cleaner that you push along the track. They do give you a measure of the rail coefficient of friction. It does do its job when it works. It's sometimes just a little hard to get started.

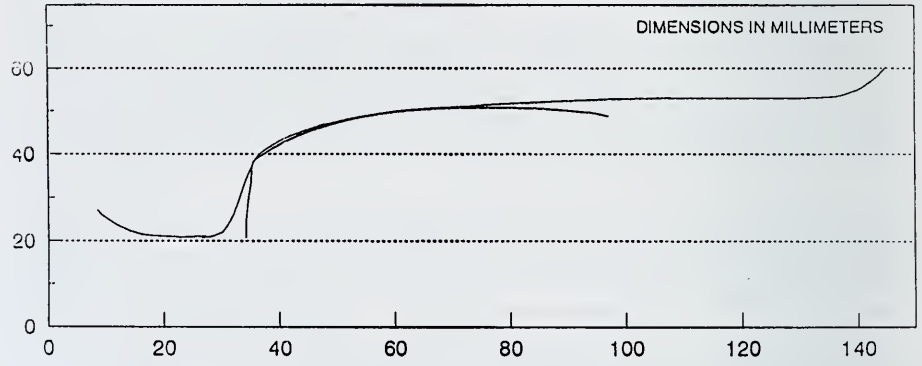

40
20
0
Pre-Grind
Grind #1
DIMENSIONS IN MILLIMETERS
0
20
40
60


40
20
0
Pre-Grind
Grind #2
DIMENSIONS IN MILLIMETERS
0
20
40
60

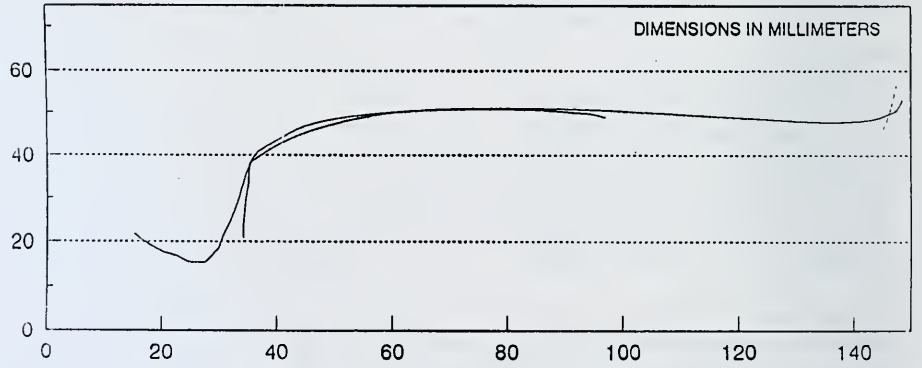
New AAR1B Wheel on 2nd Grind High Rail



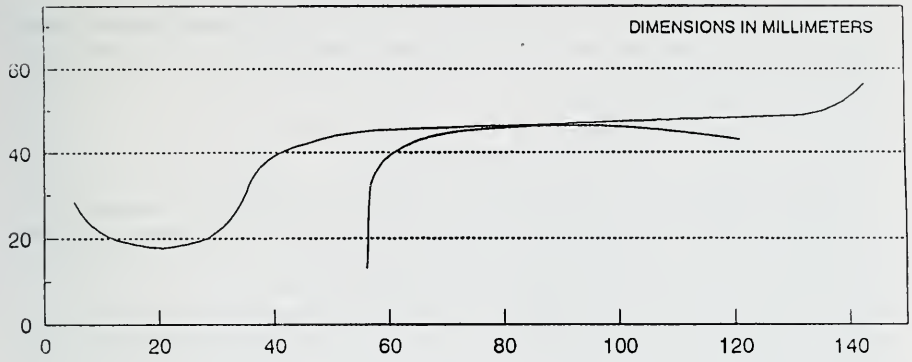
Average Worn Wheel on 2nd Grind High Rail



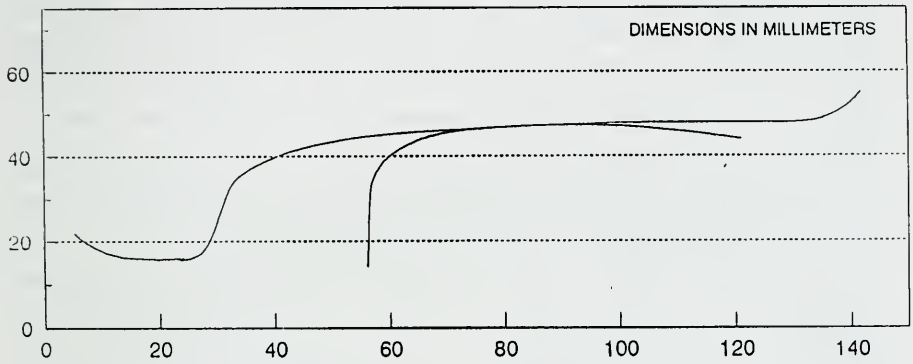
Severely Hollow Wheel on 2nd Grind High Rail



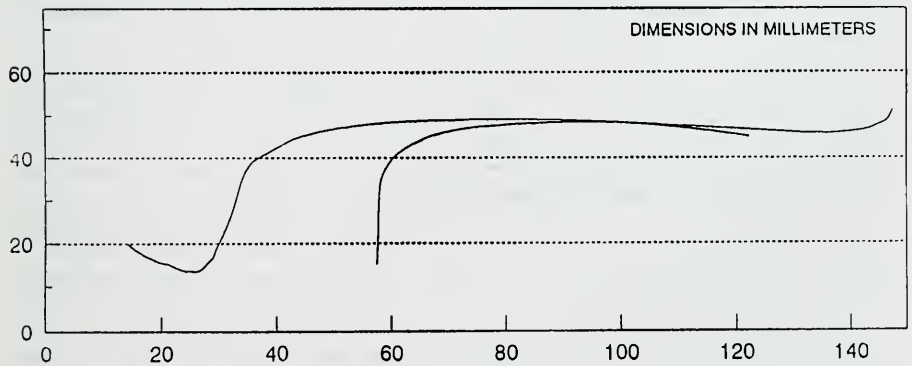
New AAR1B Wheel on Post Grind Low Rail



Average Worn Wheel on Post Grind Low Rail



Severely Hollow Wheel on Post Grind Low



These are pictures of what different friction coefficients would look like on the rail. On the low rail if you see a bit of a black streaking or little bit of black specking on the low rail that is a pretty good lubricated rail. That's a coefficient of friction of about .23 which is really pretty well lubricated rail by all accounts. Now dry rail would be in the range of about .45 or .5 or .55 or somewhere in that range.

This is a high rail with a coefficient of about .35. Again, there is a little trace. It isn't that dark but we still have some lubrication down on the rail.

This is the typical lubrication pattern that a locomotive flange lubricator will put out. They look like little dollops of grease along the gauge corner. You might have seen that before.

Here is a well lubricated rail after a high rail lubrication system went through. You will see a darkening band or a darkening cast through the head of the low rail. That is a good lubrication condition. That's what you ought to be looking for out there.

Now, this is a chart showing the results of different lubrication conditions. This is the mean or average low rail force measured on about 20 or 30 test trains through the test sites. The blue bars are what we would describe as poor lubrication conditions. The red bars are good lubrication conditions where we put some lubrication down on both the low rail head and some minimal lubrication on the high rail as well. Now let's look at what happened. We started off with good lubrication in red. The average forces are quite low. We gradually let the rail dry out after three or four train passes. You will see the lateral forces nearly double as that low rail dried out. It only took a couple of trains to do it. It doesn't take a whole bunch of traffic to dry the rail out. If you are in heavy tonnage territory, two or three coal trains will completely dry your rail out in the right conditions. But you see how the forces nearly double. We weren't derailing trains here but just think what that is doing to your ties and fasteners and rail wear, et cetera.

Then we came back and lubricated. The forces go right back down. We dry the rail out, they go back up. We lubricate again and they come down. Then we let the rail dry. We were doing some other tests as well and we let the rail dry and they stayed high. Finally, we lubricated one more time and that brings it right back to about half again.

That's how you can manage, with proper lubrication, these forces that are put into your track structure. You can probably cut them nearly in half by a good lubrication program. That's money in the bank as far as rail wear, tie wear, fastener wear, maintenance, et cetera.

We have some statistical plots if you are interested. These are percent exceedances. Basically without favorable rail lubrication conditions we are getting about ten percent of our hits with 15,000 pounds of force. There's a few about 20,000. This is about the limit of our cut spike system. Around 20,000 to 25,000 pounds lateral is where we really start over stressing a cut spike to where it starts losing its elasticity. You can see with unfavorable rail lubrication conditions you are putting your cut spikes into jeopardy with the number of trains. Statistically it's not as great, but it's still significant.

The L over V ratio is the same kind of deal.

Here is another series of tests on a different railroad, different curves, and different conditions. These are all red bars but what I want to illustrate is this was a lubed rail condition under heavy commodity trains. Then we let the rail dry out and it got very dry so the forces went up. We came back and lubricated. We let the rail dry or we dried it again. We relubricated and we could manage again. We could cut the forces in about half.

If you want to know how we dried the rail out so quickly, mops and gasoline does it quite well. We went out to try and control this. We just mopped the whole rail with gasoline and it got the rail dry. This method got all the lube off very quickly so we could make some quick changes in rail lubrication.

Again, you can see how we can manage or bring those forces down and let them build back up with dry rail and bring them straight back down again. Statistically it's the same sort of deal. With dry low rail we will get a bunch of hits out here in the 15,000 and 20,000 pound

range which is what is doing the damage. These are the significant few that are doing the damage to your track structure.

You have been through quality classes with all this good stuff lately. You have seen the Pareto analyses and Pareto charts. The law of Pareto says that 20 percent of your employees do 80 percent of the work. Well, the same is true with curving. Twenty percent of your hits occurring way out in that over stressed region is really putting a lot of force into your track structure that you don't want.

Now, for my conclusions. We found that moderate lubrication of the low rail head with a friction coefficient of .3 significantly reduced the lateral wheel set forces. Now, it might seem a bit strange to lubricate the head of the low rail. It certainly did to me when I first heard it. How do you achieve that? I will tell you one thing how you don't achieve it. You hardly can achieve it with wayside lubricators. Those are flange lubricators basically and they depend on flange contact to pick the grease up and carry it through a curve. Guess what? You are not flanging on the low rail. So those lubricators are largely ineffective in obtaining some coefficient of friction reduction on the low rail head. It almost has to be done with either a high rail mounted system or locomotive mounted system to get good coverage on the head of the low rail.

We also found that moderate lubrication on the low rail significantly reduced the percentage of warped trucks. These are the bad actor trucks. So, again, we see this symbiotic relationship between rail conditions and mechanical performance. When the rail is dry, the trucks didn't steer. When the trucks don't steer, they go into the warp. When they do that, they are trying to spread the gauge. We saw a large percentage increase with dry low rail.

Now, I have a caveat. Rail lubrication must be closely controlled to prevent tractive effort problems as I said earlier. A little bit can be too bad. If you go out there and slop the hell out of the track with grease, your locomotives are going to start slipping. Then you are going to get a lot of flack from that. So you have to balance these two things. Not too much and not little but somewhere in the .3 or .4 range on the head of the low rail should allow adequate traction, shouldn't cause a problem, yet allow you to achieve that significant reduction in the forces that damage your track structure.

We just did a test on a major coal hauling route. We were playing with the whole idea of how much lubrication will cause a locomotive to slip. To be honest with you, we found out that as long as we kept the lube in the .3 range or so, we didn't have a real problem with wheel slip on the locomotives. So it can be achieved. You can have your cake and eat it, too.

Let's move into profile grinding. What we are going to look at here is the very controversial topic that you have read about if you get Railway Track and Structures or Railway Age or Progressive Railroading magazines. They have all had articles dealing with this controversy between profile grinding and conformal. AAR is saying one thing and others are saying something else. If you have been to any of Gordon Pachinski's seminars that he has on rail grinding, you can hear the debate raging in the hallways and the conferences about this whole topic. It's a good, healthy debate but nonetheless there are people who have become polarized on either side.

Again, we find with this issue you can almost have your cake and eat it, too. You can grind moderately two points not too excessively and relieve those gauge corner stresses and the TDs and the defects. You can still promote a fairly good steering force. However, it takes good management to achieve that.

In our testing, we looked at both the high and low rail profiles and we actually did controlled grinding tests. We came through a curve with a 16 stone deal and we put on a prescribed grinding profile and we very accurately measured it. We really controlled what we were doing. This is revenue service testing by the way. This wasn't a laboratory deal. We looked at mixed freights and then some commodities. Profiles were measured by both the laser rail managing system as well as what is called a mini prof. A mini prof is a handheld electronic rail profile measuring unit. We also varied the lubrication in conjunction with this.

You have all seen one of these monsters grinding off your rail. Some would say it's a good thing and some would say it's a bad thing. Again, this is one of those questions I am sure tonight in the hospitality suite people will be talking about whether to grind or not to grind or how much should they grind.

Now, we ground four different profiles in the rail. We started with a very conformal new rail type profile. This was fairly new rail that we started with. We only had a few months of traffic on it. It still had a nice crown and nice gauge corner to it. Then we progressively started to cut into that gauge corner. We had what we call a grind number one which was a moderate two point contact. We cut some of the gauge corner off to relieve that heavy contact stress that we are trying to achieve or trying to reduce.

Then we even cut into what is called a severe two point contact which some would advocate doing to really relieve those gauge corner stresses. We then came back and even with the severe two point on the high rail we did some field relief on the field side of the low rail. So we really looked at basically four stages of rail grinding here. To quickly take you through what the lingo is, when we say conformal or single point contact we are talking essentially about where the wheel has a nice contact band across the rail and the stresses are relieved. You can get a very high contact stress right there. Some would say we need to come in and do a moderate grind where we cut that corner a bit so that these heavy contact stresses are eliminated and our defect growth or shelling or TDs and things are minimized.

Then we have what is called a severe two point contact which can occur through either purposeful grinding to that profile or sometimes just revenue wear on the track will leave you with a two point contact. Sometimes the wheel itself with the hollow of the wheel can cause this severe two point contact pattern also. Those are what people are guessing about in the trade publications and talking about in the hallways. They are talking about conformal, moderate, and severe two point. It's what we are all talking about.

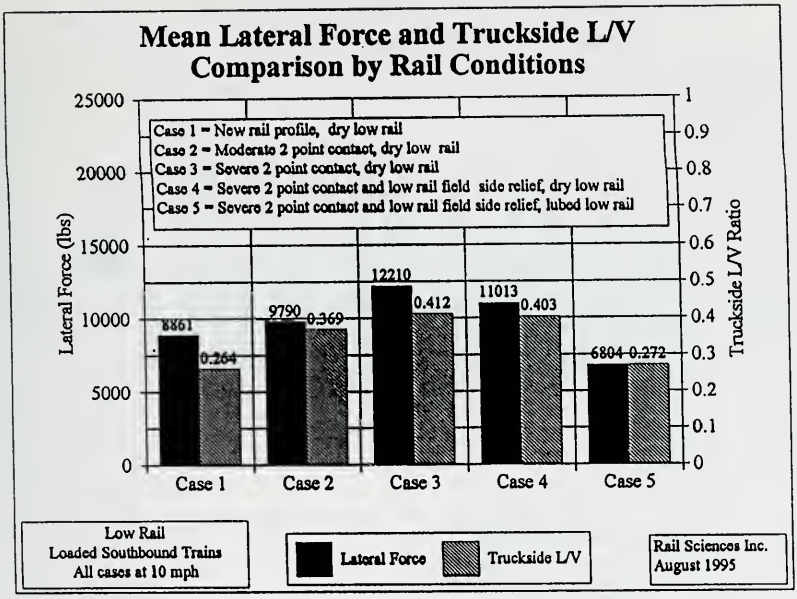
If you are not really a fan of rail grinding and this is going over your head, again, one of the prime reasons people grind the rail is to eliminate those high stresses that can form on the gauge corner. They fatigue the rail and lead to internal defects in the rail. That's why people institute a grinding program. That is a very admirable thing. We have to do that. There is no question about it. I think the results are very clear that if you don't grind you are susceptible to high defect growth rates.

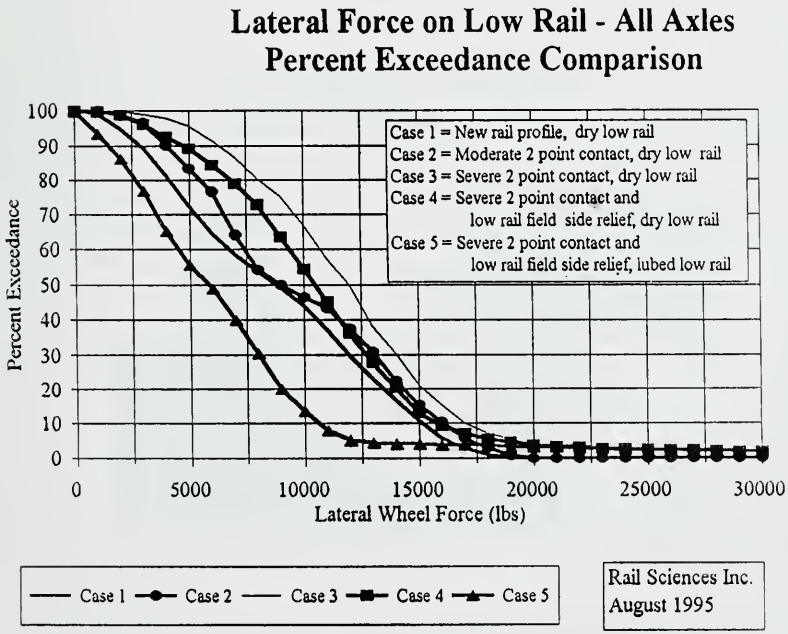
In Gordon Pachinski's last seminar one of the railroads presented some data on how they quit grinding for a year because of a budget cut. The result was their defect growth went sky high on the chart. I think it's clear that grinding is a good thing.

What we are talking about here is properly managing it. Some of the profiles are measured with the mini prof. This is the new or conformal contact and we put a new AR1B on it. We put an average worn wheel and a severely hollowed wheel down and you will see a pretty good conformal contact with all three patterns.

These are the grinds that we took. This was our moderate two point grind right here. We just set the stones up to nick that corner off. Then we really got into it hard with the 45 degree stones and took a good slash across it. So that was our severe two point grind on that new rail.

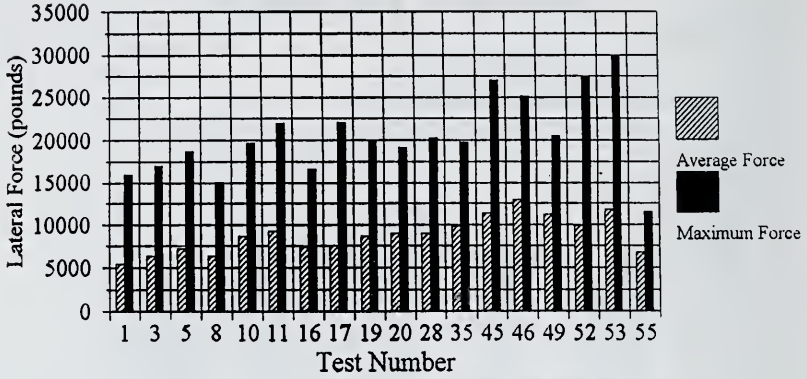
To show you some new contact geometry, this is a new wheel on the severe two point grind. We did not have any contact on the gauge corner. This is the average worn wheel that gets a little more conformal to that grind. This is a severe hollow which goes back to two point contact. On the low rail with some field side relief on the low rail we are not getting any contact except for maybe the severe hollowed wheel. Again, on the low rail what we are trying to do is keep our forces somewhere on the ball or center of the low rail. We don't want them out on the field side. We are trying to keep the forces off. When you get a hollow wheel way down it will inevitably move it out there.


Mean Lateral Force and Truckside L/V Comparison by Rail Conditions
Case 1 = New rail profile, dry low rail
Case 2 = Moderate 2 point contact, dry low rail
Case 3 = Severe 2 point contact, dry low rail
Case 4 = Severe 2 point contact and low rail field side relief, dry low rail
Case 5 = Severe 2 point contact and low rail field side relief, lubed low rail
Lateral Force (lbs)
Truckside L/V Ratio
8861
0.264
9790
0.369
12210
0.412
11013
0.403
6804
0.272
Case 1
Case 2
Case 3
Case 4
Case 5
Low Rail
Loaded Southbound Trains
All cases at 10 mph
Lateral Force
Truckside L/V
Rail Sciences Inc.
August 1995


Lateral Force on Low Rail - All Axles
Percent Exceedance Comparison
Case 1 = New rail profile, dry low rail
Case 2 = Moderate 2 point contact, dry low rail
Case 3 = Severe 2 point contact, dry low rail
Case 4 = Severe 2 point contact and low rail field side relief, dry low rail
Case 5 = Severe 2 point contact and low rail field side relief, lubed low rail
Percent Exceedance
Lateral Wheel Force (lbs)
Case 1
Case 2
Case 3
Case 4
Case 5
Rail Sciences Inc.
August 1995

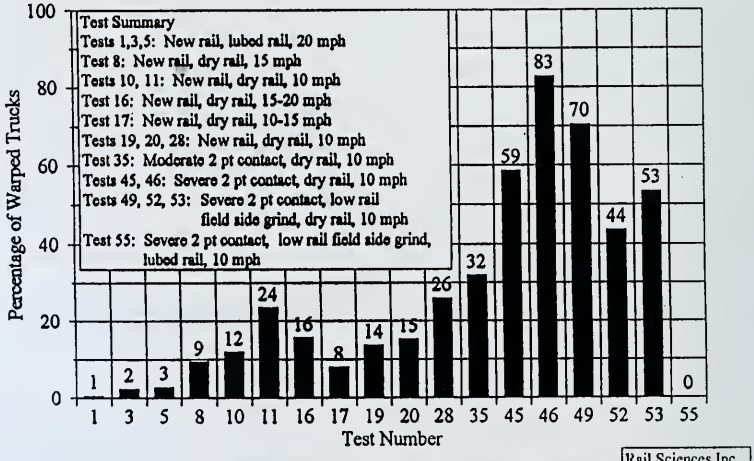
Maximum and Average Lateral Force Loaded South Bound Trains

Rail Sciences Inc.
September 1995



Test Summary
Tests 1,3,5: New rail, lubed rail, 20 mph
Test 8: New rail, dry rail, 15 mph
Tests 10, 11: New rail, dry rail, 10 mph
Test 16: New rail, dry rail, 15-20 mph
Test 17: New rail, dry rail, 10-15 mph
Tests 19, 20, 28: New rail, dry rail, 10 mph
Test 35: Moderate 2 pt contact, dry rail, 10 mph
Tests 45, 46: Severe 2 pt contact, dry rail, 10 mph
Tests 49, 52, 53: Severe 2 pt contact, low rail field side grind, dry rail, 10 mph
Test 55: Severe 2 pt contact, low rail field side grind, lubed rail, 10 mph

Percentage of Warped Trucks for Loaded South Bound Trains



Test Summary
Tests 1,3,5: New rail, lubed rail, 20 mph
Test 8: New rail, dry rail, 15 mph
Tests 10, 11: New rail, dry rail, 10 mph
Test 16: New rail, dry rail, 15-20 mph
Test 17: New rail, dry rail, 10-15 mph
Tests 19, 20, 28: New rail, dry rail, 10 mph
Test 35: Moderate 2 pt contact, dry rail, 10 mph
Tests 45, 46: Severe 2 pt contact, dry rail, 10 mph
Tests 49, 52, 53: Severe 2 pt contact, low rail field side grind, dry rail, 10 mph
Test 55: Severe 2 pt contact, low rail field side grind, lubed rail, 10 mph

Rail Sciences Inc.
August 1995

We use the old spray paint trick to visually show what we are talking about. This is the new rail and you get that conformal wear band right on the gauge corner. This promotes good steering from the trucks, no doubt about it, but that conformal wear band centered there is going to lead to defect growth. So you have to do something about that to moderate it a bit.

Then we come back with a first grinding where we widen or take a cut off the gauge corner. We moved the contact band more across the entire gauge face of the high rail. On the low side before we did any grinding we were having contact from the gauge corner clear over to the field side of the low rail. Again, a lot of wheels are running out here because they are hollow worn. That is not desirable. We want to keep it centered.

Here is the severe two point contact that we ground into the high rail after a couple train passes. You will see a lot of contact band clear across the face. So we succeeded with that severe two point contact in moving the contact across the whole rail. But look what else we have done. These are metal flakes. Those are your assets going down the drain. Again, we see that when we grind severe two point contact, we do spare that gauge corner but we also do something else. We tend to wear the rail out faster especially on the gauge corner. That wear is shown as all these metal flakes because when we lose the contact on the gauge corner we don't promote gauge steering.

With this severe two point contact band that is just an antidote I saw for the first time with my own eyes this phenomenon that had been described to me. Maybe some of you who have worked the late hours have seen this occur where train wheels are throwing sparks from poor curving performance.

I come from down south and I have had two derailments now where we have had farmers who I have been involved with say that when they saw the train coming through they saw sparks coming from the wheels. What do you actually think of when you hear about sparks coming from the wheel? I know you are not mechanical guys but you think of brakes. You think of dragging or sticking brakes or something like that. That is what we thought. But it's like the UFOs. It's always two guys from Mississippi with a little Jack Daniels who spot the UFOs. We've always been a little suspicious of these farmers who said they saw sparks flying out because we never saw the dragging brake shoe or wheel tread buildup or any of those common signs. But I have had two derailments involving rail rollover where we have eye witnesses say they saw sparks coming from under the wheels. When I ground this severe contact pattern on this rail, it was in the evening and I did see the same phenomenon. They were little sparks emanating from a very severely flanging wheel set.

So the relationship between severe two point contact and poor curving performance is pretty well documented. But it does show the defect growth. There is no question about it.

This is after we ground the low rail a bit and we relieved the field side of the low rail. We moved that contact patch right down the center again which is where it's desirable on the low rail. So a little can of spray paint will tell you a lot about how your wheels are behaving if you don't have a fancy profile reader and all that stuff.

Let's look at some results and graphs and go back to the mathematics. We have to use mathematics to level the playing field. What we are looking at here are maximums and average lateral forces for loaded trains. The reds are the average forces and the blues are the maximum force recorded for each train. We are basically in a conformal contact zone. We started to move into the moderate grind and then into these two tests with a severe two point contact grinding pattern. You can see the severe two point contact on the rail. We had lateral forces approaching 30,000 or 30 kips. That is right in the threshold of gauge spreading as far as derailment goes when you are getting upwards of 30 kips. If you take two or three trucks in a row at the 30 kip level, you had better call the wrecker out there because the track is going to roll at the lead. The two point contact grinding does not do very well.

If you're saying you're grinding two point contact, what are you going to do? Here is the good news, folks. This chart shows a severe two point grind with proper rail lubrication. By

just a little bit of rail lubrication on the low rail with that two point grind you bring that force down to half or 40 percent or so of what they were. Again, that relationship is grinding to lubrication. It's a very definite trend. It's one that I think we have proven time and again to be effective.

Here are a few more statistics for you. This is the percentage of warp trucks in the train. These are trucks that are not steering. These are trucks that go into that cockeyed position. We can measure those as well. We would see, again, the same trend with conformal contact or moderate contact, 10 or 15 percent of the trucks are warped. You go into that severe two point grind, and approximately 80 percent of the trucks were warped. So these are trucks that otherwise would curve okay except when you don't provide that steering moment for them. They then go into a warped mode.

Again, the relationship between mechanical and track is very clear. That is, if we lubricate we can bring that last band down to zero. That is a severe grind with proper lubrication and we eliminated truck warp on a severe two point grind. The L over V ratios are again conformal. Moderate two point contact, severe two point contact, and then we come back to lubrication bringing everything back down.

So we looked at it from the standpoint of L over V ratio which is your over rolling moment on the rail. We looked at lateral forces. We looked at it from percentage of warped truck. Any way you cut the deck it comes back to that. As you cut that gauge corner off, you cause the trucks not to steer as well. But the saving grace is if you properly lubricate you can come back and bring the forces back down.

If you like statistics, again, these are the statistical plots. The blue line which is case number three is a severe two point contact with dry rail. Statistically that is the worst acting situation out here. This low case is the well lubricated rail with severe two point. We kept all our forces basically at about 14,000 or 15,000.

What are the conclusions on rail grinding? Moderate gauge corner relief increased the lateral force 10 percent. Severe two point contact increased it by 40 percent. When we cut the field side of the low rail back, we brought them back 10 percent. Moderate lubrication of the low rail even brought the severe back and reduced it 40 percent. It brought it way back to where it should be.

Also, the field side relief of the low rail reduced the rail rollover turnover moment. That gets back to the fact that moving that vector back towards the center of the low rail improves the odds that the low rail will stay upright.

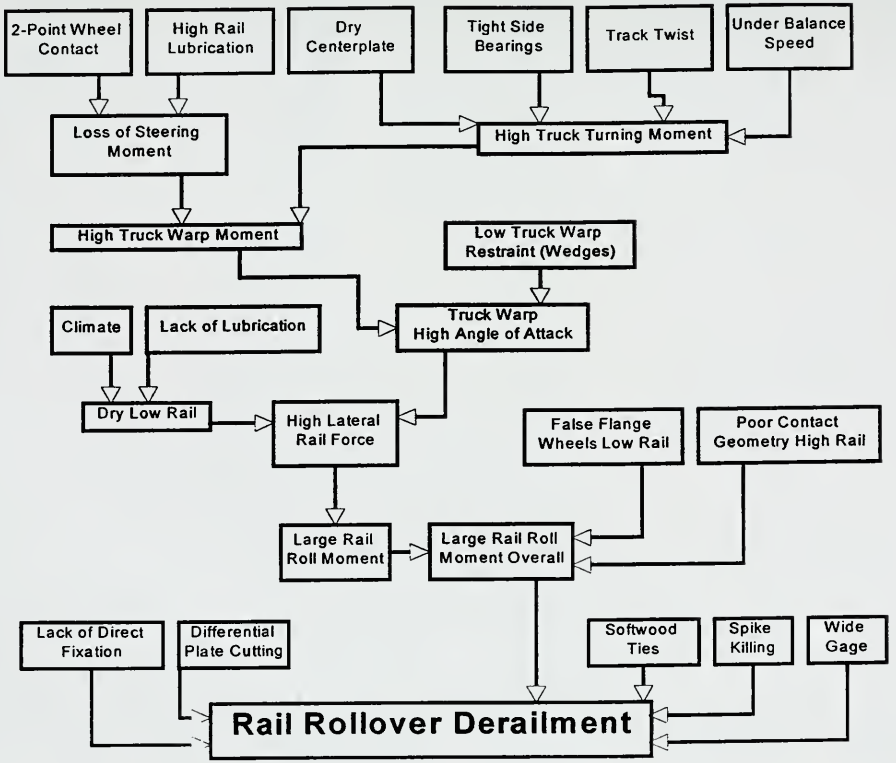
As I noted, severe two point contact caused excessive flanging and accelerated wear of the gauge face.

Now I have some other issues and these are good topics for some late night discussion. We must consider the wheel wear contact stresses that are grinding strategy. Folks like Gordon Pachinski and others out there who work in this area will tell you that you can achieve the happy balance or the happy medium with proper management. Rail defect development must be monitored with the grinding program to ensure that we are not getting into a high TD fatigue defect rate or something like that.

Accelerated gauge face wear must be balanced against reduction of defect growth in a grinding strategy and I would say there is still more work remaining on this very controversial topic. As we speak we are still doing research on it ourselves. I know Pueblo is doing research on it and probably some of your other railroads are researching it as well. But this whole idea of rail grinding is a delicate balance between good and evil. It's an area where if you do it properly, just to reiterate, I think you can have your cake and eat it too with rail grinding with a good judicial program.

Now for my final conclusions. Curving performance is a complex mechanism requiring a system solution. This isn't a track problem. This isn't a mechanical problem. It isn't an operational problem. This involves all three disciplines. But you in the room here can do your part

Relationship of Rail Rollover Factors



of it and you have seen that your part can do a lot to minimize these forces. We can't do a whole lot unfortunately about the wheels out there. You can cry about mechanical problems and this and that, but let me tell you those wheels are legal. The mechanical guys can't change a hollow worn wheel out and bill and the owner for it. He has got to run those wheels. They are legal wheels. However if they are hollowed out, we know they are going to lead to adverse performance.

There are things that we can do with our assets, the track structures, to minimize the effects of those wheels. Proper control of high and low rail profile can minimize the development of lateral wheel rail forces. We have seen that. Preventative grinding can minimize contact stress and wear rates. I think those of you who grind are well aware of that factor as well.

Before beginning a grinding program, I would ask that you ensure the curve geometry is correct. That is your alignment and elevation in the curve. One of the worst things you can do is say we need to grind and call Pandrol up or whomever, go out there and start grinding. You then find out your curve is overelevated or underelevated. This is going to affect the whole way that those wheels impinge upon the rail. So get your curved geometry correct first. Get your elevations correct and then start your grinding program.

A consistent and monitored low rail lubrication program is essential. Again, I would come back to the thought I believe a high rail mounted type system is the best way right now to do it unless we see some major changes in locomotive flange lubrication technology. Norfolk Southern is experimenting with a very interesting idea of what they call a consumable lubricant where the third or fourth locomotive in the consist or the trail locomotive in the consist is applying a consumable lubricant to the top of the rail. After 80 or 90 cars, this will be worn away. So the next train that comes along will see clean rail again. That is a very intriguing idea and I think they are having some success with that. We may see more development of that kind of thing.

Whatever you do if you are going to grind rail, by all means get some lubrication down immediately after that grinder goes through. I am talking about immediately. Not two days or three days later, but within ten minutes. Get some lubrication down on that freshly ground rail. Because when you grind rail, you dry it. You dry it really good. You get it up in the .6 coefficient range and the next train through there is going to really try to spread gauge.

We have had a number of derailments after the rail grinder was put on the side track and the first train through spread gauge on us. I have had two or three like that. If you are grinding by all means get a lubricator out there immediately behind the rail grinder and get that rail greased up so that the trains aren't getting into trouble.

A conformal to moderate two point contact on the high rail can minimize your lateral wheel set forces. A moderate relief on the field side reduces the low rail rollover moment. As I said, a high rail mounted lubricator is required to get this low rail lubrication done properly. It can't be done by wayside lubricators. Locomotive flange lubricators, when they work, just do a really good job with the present technology.

Now, as I said at the start of my program, there are six things that must occur for rail to roll and I am going to finish up with that sixth item which is rail restraint. I have just a few remarks because this is your bailiwick.

You are out there maintaining track and these are the things that you can do on the rail restraint side. Forget all this other stuff. You aren't grinding. You aren't lubricating. The wheels are bad. The trucks are bad. The operating department is running under balance speed. Woe is me. The ultimate thing you can do is make sure your rail is heavily restrained. Obviously the best would be an elastic fastening system but not all track warrants that. If you have a cut spike track, what can you do out there to prevent the rail ultimately from rolling?

Well, when we talk about poor rail restraint we talk about these things. We talk generally about cut spikes and wood ties and spike killed ties, web ties, soft wood ties, raised spike conditions, insufficient spike patterns or single shoulder plates. I would say raised spikes is the

issue that I see a lot that preexists before the rail rolls. Every train as you see is trying to cant that rail and push it out. When you get the spike head up about a half an inch or more, you pretty well kiss it goodbye as far as providing any rollover restraint to the rail. It's pretty well gone once it gets up half an inch. I have had roadmasters say, "Well, that's normal. We have a lot of spikes that high." Well, that's not a good situation. Spikes need to be down. Again, you want some breathing room in there but you don't want them up a half inch or three quarters of an inch because they have probably lost their rail rollover ability at that point.

This is our old buddy the cut spike. A lot of the throat cutting that occurs is a sign of excessive fatigue in the spike. We have even had cases a few years ago of a bunch of broken spikes occurring. When you start to throat cut a spike, it's a sign that it's wearing. It might be spike killing the tie as well.

Here is our familiar spike kill condition. When I say raised spikes, I'm talking about spikes that are up. We also have the differential condition here. There are some split ties and tie ends that are split. The splits come right into the tie area. If that rail wants to roll or tries to roll these spikes are largely ineffective once they get into that condition.

This is our example of a spike killed soft wood tie. There are largely rounded out holes found in this situation. The spikes are probably pretty loose in the tie.

The differential plate cutting, again, I mentioned to you earlier. When you have the plate sitting pretty proud on the tie, our forces are such that our loads are out somewhere but as we differentially cant that rail it moves that point of load application way out. That is your rollover moment protection. It's much smaller at one location than it is at another. So it only takes a bit of rail canting to really set you up for a potential rollover.

Here is a tie plate that is standing proud on the gauge corner but out on the field side it has pretty well had it. It is really canting.

Here you see heavy cutting on the field side and not much on the gauge side.

Now to finish up, prevention of rail rollover is, as I said, a systems problem out there. Ironically we must have many contributory factors coming together at the same point in time. Rarely can I find a single event to blame. As a derailment investigator, everybody wants me to name a single item. I have to tell management that it isn't that simple. There are three or four things out there that are happening. They don't like to hear that, but we have to understand as managers that it is a system problem and there are a series of factors involved.

There is a probabilistic element in the occurrence of rail rollover. I can't explain it. How do we get two or three bad trucks in a row or the rail is extremely dry this morning, et cetera, but all these things come together. There is a probabilistic element in it. Whenever we have probabilistic elements, we have to deal with risk minimization. To minimize risk we have to attack it on all fronts. We have to attack it on the track side. That would be specifically lubrication, grinding, restraint, tie condition, et cetera. Mechanical fellows are working on these things, believe me. They have learned their lesson about side bearing clearance, center plate lubrication, and wheel profile, and the things that they need to do and they are working on those. I deal with those folks a lot. So I know there are efforts there.

We continually work with operating departments trying to optimize curve speeds so that we are not running considerably over or under balance in a curve. Those are the three things that we have to manage.

That brings me to my time limit, Ken. I would be happy to address any questions from the audience.

Member: How do you lubricate the high rail with a high rail mounted system when you can't get track time?

Mr. Wolf: I agree that this is a real problem. You take some of these real heavy density corridors like the North Platte Sub on Union Pacific or Crawford Hill on Burlington Northern and some of these places that have really heavy density traffic and it's a problem.

We found in tests in some of these areas that rail will dry out after three or four coal trains. So it is a very difficult problem. I think, though, that if the solution comes from management

and not just from the track side, but if operations realize the significant savings that a good lubrication program is getting you might be able to squeeze a high rail inspection trip in there.

Now, another promising development is better locomotive mounted lubrication systems. We had a few activities on this front. As I said, in essence one is playing with this idea right now and I think ultimately a locomotive mounted system with some smarts in it such as a computer maybe that knows the trail unit and things like that will ultimately be the way to achieve this. But that isn't for everybody and it relies on locomotives. You know how bad those mechanical guys are at maintaining stuff. So it may not get done as well as we like. I don't know. I wish I had a good answer for that one. It's something you have to work with your dispatcher on.

Member: We had locomotive mounted lubricators in the past ten years and they did good job but then the maintenance has kind of fallen off.

Mr. Wolf: I would agree with that. I have seen Conrail put a number out a few years ago in a paper that they had studied their locomotive fleet. I think over half or 50 percent of the lubricators were not working or were turned off on their locomotives. This is a fact of life. That's why I say you can't do it entirely with the track side or high rail. You need all three of those things working together. Locomotives can do a pretty good job if they are maintained. The other problem is engineers get on these high adhesion locomotives. If you have ever ridden one of these big Macs or these AC units that are out there now, their wheel creep and control system will cause a bit of shuddering in the engine. An old head engineer thinks that's wheel slip. What is the first thing he does? He cuts the lubricators off. That's just the way the system works.

It's an educational program. Again, it must come from management because as you said you get your four or five percent fuel savings. Who gets that? The transportation department. Who maintains the flange lubricators? The mechanical guys. So you go figure. That's why it isn't as good as we like.

Member: On the issue of lubrication we have been doing some very interesting work in the last year or two concerning the point you brought up in the presentation on moderate lubrication and the concern of putting too much on and that you lose your propulsion with the locomotives. What we are doing is some work with Dr. Calusic of the National Research Council who has come up with the various types of what are called friction modifiers. These have very specific windows of coefficients of friction. Recently they have a liquid version of that. What you can do with one of the versions which is the immediate level is you don't have to worry about over applying like you would with traditional types of grease. It gives you an operating ratio of say between .2 and .3 regardless of how much you put on.

I think you intentionally want to over apply because that would keep them cold.

The other thing we have noticed that we don't think many people bring up in these types of discussions is a big benefit not only the reduced lateral forces which in themselves is a big factor but also the reduced factor or impact that it has on pocket rail wear. Imagine if you only have half or 20 percent of the lateral forces. Those scuffing types of marks that we saw on the slides don't happen to the same extent. So your vertical wear, not just the gauge wear, we see the particles coming down, is affected. You are obviously not wearing your rail especially in the low rail. We found it's a big impact.

One other comment that I think is very important and I would very much like to have people take back to their railway offices and tell the people at higher levels is this issue of one and two point contact. For some reason, it appears as though most people think there is only two things. They have a one point grinding or two point grinding. That is not the whole story. What is available besides this is what is called strong two point contact. It's the whole multitude of two point contact all the way down to the point where we have only one form. The type of grinding that we are recommending and other people are adopting is like a very subtle or weak two point contact. That is a whole different ball of wax than this strong two point contact.

Unfortunately I think there are a lot people who don't understand that. So we are trying to make people aware of a very big difference of strong and weak two point contact, actually weak to the point where you are almost on one point. You are just relieving the gauge corner enough to get the benefits of the steering but to relieve the high contact stresses.

Mr. Wolf: Those are some excellent points. I hope that's the one message that you take from my presentation. We are not in a polarized environment either. We grind conformal. We grind two point. That is the way the publications put it sometimes. But Gordon said there is a big gray band in between and that is so true. We saw that you can grind that conformal. You still achieve good steering and I hope you reduce those contact stresses. But you have to monitor it on your own railroad to be sure. So I think there is, as Gordon said, a little ground in there where everyone can be happy with that.

He is so right on the vertical wear as well. If you reduce those lateral scuffing forces or creep forces, you will also save that low rail from being flattened out.

I'll end it here and I do thank you.

President Koff: I do so much appreciate your coming down again, Gary. Thank you. (Applause)

As I said, I do enjoy this topic and the topic of managing our rail assets. Now building a little bit on what we talked about this session just now with Gary, you will see on the green sheets for next year there is a topic in there called changes in under balance. What this refers to is not changes in the under balance formula, but it's changes that we all see in the application of that. It is also how it's going to relate to how we are going to manage our rail and what the implications are of running a wider band of under balances on our properties.

So thank you again, Gary.

Our next speaker is Bob Kramer. He is vice president of world sales and marketing for Fairmont Tamper. Bob also serves as this year's president of REMSA. We really appreciate him being here at our conference today as we do appreciate the hospitality we share with REMSA. We share a partnerlike relationship in a number of the things we try to do here at the conference.

I am trusting Bob will speak to a couple of those things. I ask you to welcome him here with us today. (Applause)

INNOVATIONS IN WORK EQUIPMENT

Bob Kramer

Fairmont Tamper

Good morning. As your agenda says, I am Bob Kramer with Fairmont Tamper. I am here today not on behalf of Fairmont Tamper, but on behalf of REMSA. I have had the honor of being REMSA president for the last six months.

My presentation today is not going to be about new products or new specific technologies. I am not going to stand here at the podium and run through slides of new plow designs or work heads on tampers or seats for your operators. Those are all good topics, but I would bet that most of you when you have been back home or out on the track have already had those sales presentations. You have heard a lot from the suppliers about their individual technologies.

What I would like to do today, though, as president of REMSA, is take this opportunity to talk about the suppliers themselves and the roles the associations play in our industry. All

of the actions and all of the work that all the suppliers do are really there to serve your industry needs to make your jobs easier, safer, and more productive. Too often in today's environment it becomes easy for both suppliers and customers to forget that neither succeeds without the other. As the North American railway industry and supplier association grow and react to the changing environment, all parties must be involved and prepared to cooperate and communicate to work towards common goals.

I would like to take this opportunity to talk a bit about how I believe suppliers, REMSA, and our other sister trade organizations fit into this picture and specifically some of REMSA's plans for the future.

Since I am a sales and marketing type, I tend to think of presentations in terms of customer needs and benefits and what are the costs involved in obtaining those benefits. I would like to spend the next 15 minutes or so talking about what I see are the needs of the industry that REMSA and the other trade associations in our business have tried to address and why there are trade associations. How have we addressed these needs specifically and what are the costs incurred to gain those benefits? How do you individually and your companies as a whole actually benefit from some of these? Finally, just as Roadmasters, B&B, and AREA are taking a proactive position in industry changes, so too is REMSA. I would like to give you my thoughts about how things are changing and what our plans are for the future and how we intend to react.

With respect to the first topic of what the needs are that I believe were fulfilled by suppliers and associations, perhaps the easiest way to answer this question is for you to ask yourselves what do you need to get your job done the best that you can? There are certainly lots of answers to this question but in my view the primary theme has to be centered on education and information. None of us can work in a vacuum. Knowing what is going on around us is a daily requirement. Keeping up to date on new technologies, the best practices, and, yes, even the mistakes the guy next door made are all important facts that we have to have in order to do our jobs well. We must provide constant improvement. That's required by the business today.

Providing a means and a forum for communicating these issues is another need fulfilled by suppliers and associations. All of the information in the world is of no use if there is no means by which to provide the communication and spread these good words about the advances in technologies and things of that nature.

The third item is resources or more precisely the lack of sufficient resources. This is a growing factor within our industry today. I am positive that everyone in this room has been asked on a daily basis to do more with less. Just as technology and the need for more education grows, the resources of time and manpower necessary to fulfill these requirements diminishes. Don't we find ourselves all asking or wishing that there were more than 24 hours in a day to get our job done.

Another area and one which is often overlooked or at least hidden from our day-to-day activities until the inspector comes around is government involvement. The federal government needs our industry input as it formulates its policies and procedures covering everything from work rules to equipment specifications. We need to promote to the government what our requirements are and what is going to be best for our industry as a whole. Their policies affect your daily activities on track and the cost of equipment and business that is going to be generated from outside the borders of the United States. Too often we focus just on what is going on in North America. Our businesses are affected a lot by what goes on outside of our borders.

Finally, the most common thought that may come to mind when REMSA is mentioned is sponsor of events such as the coffee bars that we have had here, the hospitality suites, and the cocktail parties. Certainly these are events that are fun and relaxing. In my opinion, though, they are also one of the better way to promote informal communications and ideas. It is easy to say that these are extracurricular activities and maybe outside of our work, but how often do you stand at these functions and not talk about railroading? Whether we like it or not, our

industry is a very close-knit group of people. Railroaders tend to talk about railroading. We are a pretty boring bunch in that respect.

So these are the five needs that I see as being required by the industry and that we address as an association and our suppliers do as individuals.

Now that I have talked a little bit about the potential needs, let me spend a few minutes talking about REMSA since that is the organization that I am obviously associated with and how our trade association tries to fulfill those needs.

Just as your organizations have had a long and venerable history, so has REMSA. REMSA as a formal organization was incorporated in 1965, but that was the putting together of several other organizations that had been around for quite a long time. One was the National Railway Appliance Association started in 1936, Track Supply Association which began in 1910, and finally the Bridge and Building Supply Men's Association which apparently predates recorded history because no one knows when it started other than in the late 1800s.

Interestingly enough, the charter of the organization that was created in 1965 focuses on education. I am going to read a small portion of that mission statement. "The purpose of this organization shall be to promote the welfare of the transportation industries and carrying on the activities of its predecessors. Its activities shall be wholly educational, looking to the greatest advancement in the efficiency, safety, maintenance, and operation thereof. It will cooperate in the development of conventions of engineering, maintenance, research, and scientific associations. It shall sponsor and hold exhibitions of equipment, appliances, and supplies held in conjunction with these meetings."

You can tell from this mission statement that from the early beginnings of the organizations, education was its main mission in life. It is perhaps worth noting that I am focusing on REMSA as I said since I am president of the organization, but there are lots of other supplier organizations out there, such as RBI, RSSI, and NRC. All of these organizations in one way or another attempt to satisfy your specific needs and the general needs of the railway industry as a whole.

Again using REMSA as an example, let me highlight how we attempt to fulfill those specific needs that I have mentioned. Typically when the term REMSA is used it is associated with the big equipment show. Many of you probably attended the show in Denver several years ago. The next show will be one year from now in Kansas City. Not only has REMSA traditionally sponsored this big show, but in recent years there have been the smaller mini shows held at the Palmer House. The mini shows began as a way to promote and add education and product knowledge in between the big shows.

As you would expect with the impending reorganization of your groups there has been much discussion within our own ranks about the future role and pattern of the exhibits. The current thinking right now is to have some form of exhibit every other year based on a six year cycle. There would be two mini shows followed by a major show. So there would be a mini, an off year, a mini, an off year, and then a major equipment show.

An area that has received growing attention from REMSA and its members is participation in various other industry committees. I know in the work equipment side which I am involved with, Committee 27 has had increased participation by the suppliers within the industry. In another area recently I had the opportunity along with Jim Beran to give some opening remarks to a track turnout seminar sponsored by Committee 5 here in Chicago. Suppliers were an integral part of that two-day seminar where they talked about research, current developments, and problems that were being had.

REMSA also has a place on the AAR Heavy Axle Committee as it assumes responsibility in the form of FAST Steering Committee.

As technology and our business environments change, so too does the availability and requirements for resources. With fewer and fewer people working directly for the railroad, more and more reliance is being placed on suppliers to provide expertise, technology devel-

opment and manpower to help development industry standards and education. Active participation in committees and seminars is one way that suppliers can help.

Another area of REMSA involvement is government dialogue. You can read that lobbying. You can read that anyway you want, but it is discussions with the federal government. This tends to take two directions. One is issues relating to policies covering North American railroad organizations and programs, and the other is programs designed to promote the railway industry involvement outside of the borders of North America.

I am pleased to say that Jolene Molitoris, the FRA administrator, has on several occasions requested REMSA and its members to participate in various round table discussions dealing with industry issues. Regular participation by our member companies in other lobbying organizations such as RPI also helps provide input to the government on issues from safety to equipment specifications. Right now there is a series of meetings going on in Washington that have been dealing with the unions, the suppliers, and the railroads. We are dealing with these sorts of issues of safety and equipment requirements.

REMSA also from time to time mobilizes its members to provide input through their Congressmen on legislative issues relating to industry topics. The most major issue in recent times has been the highway laws dealing with trucks and long trailers.

Another area that you probably don't think about in your day-to-day activities is North American railroad involvement in countries outside of the United States. Along with the U.S. government, we have been involved in promoting railway industry expertise outside of our country. If you follow the media you know Wisconsin Central is heavily involved outside of the U.S. Several U.S. railroads have bought or are operating railroads in South America and many railroads have consulting arms that are doing business around the world. This is all business which may not affect you directly in your day-to-day jobs, but certainly provides revenues and profits for your companies.

REMSA is involved in promoting our industry abroad. Judi Meyerhoffer, our executive director, has accompanied Ms. Molitoris several times and once to the Pan American Railway Conference. We have been given several opportunities to travel with the Commerce Department to promote our industry abroad.

One last area where REMSA provides a service to the industry is event sponsorship. As I mentioned earlier, informal communication in my opinion is as important as the formal kind. REMSA puts a great deal of resources into providing an environment that promotes the exchange of information and friendly relations. Whether it's the coffee bar or a board of directors dinner or the hospitality suites here at the conference or any other number of meetings that we host during the course of the year. These events provide a friendly atmosphere to develop relationships and catch up on business.

Of course the punch line is what does it cost? As a typical customer you ought to be asking yourself what does it cost for all these wonderful things? There is no such thing as a free lunch. Surely one way or the other these expenses get rolled into the prices of the products and services that you buy from REMSA suppliers. Strictly speaking from an accounting standpoint, I guess that is true. Costs have to go someplace. But, in fact, the cost that we deal with REMSA are extremely low. The dues that we pay compared to any other supplier organization are the lowest that I know of. We are also able to do all these things for a couple of other reasons. First, we operate with a very small staff. Judi Meyerhoffer, our executive director, and Helen Pape, her assistant, could probably tell you in a drop of a hat how low we operate in terms of expenses.

Secondly, much work is conducted by our board who are all volunteers and are all people you know in the industry. Our work is generally conducted during our normal course of business when we are traveling or working on our normal business trips. In this way, there is no real extra expense for our companies and no added monies that have to be built in.

Thirdly, associations, whether it's ours or any of the other associations, work on an economy scale. That is to say, what might be too expensive for one individual company or small group of companies to do becomes much more cost effective when you have 202 members such as REMSA does. There is power in numbers.

Finally, I pose the question what would it cost if the associations weren't there or if the suppliers weren't there? If for no other reason than the lack of time and manpower in your every day jobs, how would the industry cope if you were asked to take on these many other activities in addition to what you do normally? This doesn't even consider the confusion or lack of focus that might result if there weren't organizations whose main goal in life was to put together conferences such as these or put together equipment shows. From technology development to equipment show planning, it takes the resources of both suppliers and the railroads alike to handle the job.

What is the benefit? What do you get for all this? Well, as I have already said, REMSA's primary mission is education and I believe that is the payoff. The success of our respective companies is a two-way street. Suppliers need to understand your technical and practical problems and the railroads need to know the hurdles that the suppliers face on a day-to-day business. Railroads need to know about the technologies that are being developed by the suppliers and how those technologies can make us more successful.

Over the years some companies on both sides have taken the attitude that they want to be smarter than the guy sitting across the desk from them. I think times are changing and I think that attitude, the attitude of today, is more that knowledge is power. The more knowledge that we share between the suppliers and the users the greater the chances of success on both sides of the equation.

As a supplier, I can say that any development, commercial, technological, or regulatory, any development that makes my customers stronger in the long run is going to pay off for my company. It may be painful in the short run such as the major downsizing of past years, but in the long run a stronger railroad means a more stable customer for me and I think that's good. I believe that many railroads share the same attitude today about their suppliers. I think that kind of attitude has changed. Suppliers cannot develop new technologies and help solve your problems unless we all get exposure to each other's needs and requirements and have the opportunity to share ideas.

What about the future? Well, the short answer is probably more of the same. However I would add that the challenge would be to evolve and modify all of these functions as our industry changes just as you are trying to address those same needs. I believe based on discussions with some of your board members that increased emphasis on the quality and quantity of committee work, technical conferences and seminars will be of primary concern in coming years. REMSA believes that our many members can contribute to these expanding services.

As I said earlier, REMSA has been actively involved in planning for the potential consolidation of your associations and conferences. We hope to maintain that participation as a formal member of the conference planning committees in future years. We hope that we can be of assistance in growing those and expanding those. Like it or not, federal government isn't going to go away. Participation and involvement in our business lives is always going to expand. REMSA and our sister organizations recognize that silence on some of these matters is not the course to take. We will continue our active involvement in legislative issues to ensure that the best interests are served by the government.

Finally, REMSA certainly plans to maintain the sponsorship of events and equipment shows. We are constantly looking for the most efficient manner in which to bring these events to the industry and tailor our shows to your requirements.

One more plug for our show in 1997 in Kansas City and I should also mention that REMSA will be conducting a mini show here in Chicago in 1998 as a kickoff to your first year as the newly consolidated association.

Any of you who have given a presentation know the old formula for a speech:

- Tell them what you are going to say.
- Say it.
- Tell them what you just said.

Well, what I just said can be boiled down into one sentence.

We need each other.

REMSA and its members need you, our customers, and the railway need us, your suppliers.

The business environment has changed and continues to change at a lightning pace. No one company or organization has the resources and capabilities to go it alone.

Education, Communication, and Information is the name of the game today and our industry has recognized that it is a whole lot easier when we work together as a team.

Thank you for your time and attention.

BRIDGE AND BUILDING SESSION

Tuesday Morning

Mr. Lileikis: The first presentation this morning will be introduced by Bob Carter, junior vice president.

Mr. Carter: Good morning and welcome to the first breakout session of the Bridge and Building session for Tuesday. It gives me great pleasure to introduce our next presentation, Concrete Erosion Deterioration Diagnostics. Our presenter is Michael Boyer of Applied Engineering and Sciences. Mike completed his Bachelor of Science and his Masters of Science degree in civil engineering at the University of Missouri in Columbia. He was formerly with Georgia Environmental Protection Division in industrial wastewater regulatory programs and emergency responses and also served as regional manager with other consulting firms.

Mike founded Applied Engineering and Science, Incorporated, in Atlanta, Georgia, in 1980. He has also managed several hundred railroad environmental and facility projects including tracks, yards, servicing facilities, and shops across the United States and Canada. Mike is a registered professional engineer in 12 states, a member of AREA committee 14, and the AAR environmental advisory subcommittee.

Please join me in welcoming Mike Boyer. (Applause)

CONCRETE EROSION AND DETERIORATION DIAGNOSTICS

Michael Boyer

Applied Engineering and Sciences, Inc.

Thank you, Bob.

I appreciate the opportunity to come and speak to you today. I don't know how many of you saw Jolene Molitoris yesterday, but she was an absolutely fabulous speaker. I think all of us can learn from watching people like her speak and make presentations. She talked about a subject that she is really interested in and whenever you talk about a subject that you are really interested in you can always do it with enthusiasm. Most of the preachers, for example, are very forceful speakers and really come across well. So my challenge here is to try and get excited about cracks in concrete. I will try to do the best I can.

I overheard someone saying, "What does this guy know about concrete? He is an environmental person." I do a lot of environmental work, but I do a lot of other work for railroads as well. I am a decent structural engineer. I am certainly not a structural engineering genius and I am certainly not a cement chemist or anything like that. But I do have a lot of practical experience in building things out of concrete on railroads. I also have seen some things that didn't work so I hope I can impart some knowledge to you that you will enjoy.

Yesterday you had another speaker, Dr. Gene Corley. I didn't realizes that Dr. Corley was going to speak. I don't know how many of you heard him, but he talked about a similar subject. I didn't know until about the end of last week that he was going to speak on that subject and I was not able to arrange my schedule to get here in time to hear him speak. But I did speak with Dr. Corley and got a sense of what he was going to address. So I have tried to direct my

presentation so I won't get into many of the same subjects. But if I do get into a few, please bear with me. I think the presentations will be reasonably complimentary.

One other point I want to make at the outset is this is the B&B group and I am not a bridge person at all. Most of the remarks I am going to make are about non-bridge structures. A lot of it obviously will have applicability to bridge structures, but I am not a bridge person. If you ask me bridge questions, I'm not going to be able to answer them.

I am going to call on you for a little bit of help here and ask you to recall something for me. I saw a presentation at an AREA annual meeting five or ten years ago on repair of bridge structures and it had some neat pictures of pressure polymer grout. It was extremely well done. I tried to locate it, but can't find it. If anybody knows who wrote it or who gave the presentation, I would appreciate if you would let me know. I want to make it a reference in this paper that we have put together. We do have a paper and if anybody wants a copy of it, just give me a business card. I will be around here for about 30 minutes after my presentation and then I have another commitment. If you don't see me, give your card to Bob Carter and I am sure he will give it to me.

I want to acknowledge Maureen McDonald who is my coauthor and a very bright civil engineer. She does a lot of this kind of stuff for us. As usual, I had her off doing a lot of the grunt work while I am up here doing the talking and taking the credit.

For those of you who have heard me speak before, I will invite you now to be prepared to ask questions. You know if you don't ask me questions, I will start asking you questions. The other thing I will almost always do is leave my audience with some homework when we get done so you will have something to do. This will make it a more useful exercise for you. As I said, one of your first pieces of homework is if anybody knows about this bridge presentation that I was referring to I would like to have you pass that information on to me and you will get off easy. Sometimes if I have a really good audience that asks a lot of questions I don't give homework. However, usually I do.

There is an old song or poem or something that talks about railroads running on ribbons of steel. What it doesn't tell you is that most of the rest of the facilities are sitting on concrete. Looking at a picture of a yard you tend to look at it and see the tracks and the cars, but there is a lot of concrete down there. We use concrete for lots of things on railroads. It's a very reliable substance. One of my friends at CSX made the comment and he is right that under some circumstances concrete is cheaper than dirt. If you have a lot of work with the soil, it's cheaper to put concrete down. So we use it a lot. We rely on it a lot. Concrete is like a friend. If you treat a friend well, he'll help you. If you don't treat him well, he won't.

As I got into putting this presentation together, it became clear to me that one of the most important aspects that one ought to think about with respect to repair of concrete is why are we doing it to begin with? Very few of us have ever designed or built structures under the assumption that it's going to fail or break or whatever and we are going to have to go back and fix it. That's not the mentality of engineers. Yet most of the time when you get into a concrete repair or renovation project, something has gone wrong. Somebody designed a piece of concrete for whatever purpose and it was either under designed or being subjected to uses which it was not intended. There is a whole list of the things. I am going to talk about that in a little bit. I think from a program standpoint, it would be interesting for all of you to go back and reflect on how much money you spend a year refurbishing concrete. If you had spent that money doing a little better job analyzing the application, designing, and constructing the thing, you might never have gotten to where you had to repair the concrete to begin it.

Certainly the other reason to repair concrete or renovate it is if you take a piece of concrete that was made for one application and now you are going to use it for some other application such as a shop modification. I am going to talk a little bit more about that later

So in terms of what can go wrong, there are all kinds of things and I have a list of them. There are a lot of reasons why concrete needs to be repaired. If the situation had been analyzed

correctly from an application standpoint, if the concrete had been designed correctly, and if the structure had been constructed correctly, you wouldn't have had to do this to begin with. Certainly some of them are unavoidable. Derailments, for example, with locomotives flying through the air will do massive damage to all kind of structures. I am sure a lot of you have been out there. I have had an interesting career where I have been able to go to a lot of derailments. It's amazing what will happen under those circumstances. So maybe that is a situation where it was unavoidable

Aging is an interesting plus and minus. We run into a lot of concrete that is really old in railroad applications. A lot of it we want to reuse. Concrete will last virtually forever, but it won't last forever. It just gets old. I am going to talk more about this later, but one of the problems you get into when you start working with concrete and old shops is that a lot of the concrete that was used 50 or 100 years ago is of a substantially different type of material than what you have today even from a chemistry standpoint. A lot of products that you would normally use for repair and bonding just won't work on the stuff without either surface preparation or some other type of change. It is just not the same animal. So you need to be aware of that.

Why do we need to repair concrete? I think it is interesting to look at the uses of it. We tend to think of concrete in most cases as this large mass of stuff that holds something up but it has a lot of other applications. Certainly walking surfaces on platforms, for example, spill containment, and aesthetics. Most concrete that we use has multiple uses. We are doing a lot of different things with it. So when you talk about repairing it you need to look at the use of it. I think maybe the simplest example is if I have a locomotive servicing platform walking area that has a lot of spalling and surface deterioration. That can be a problem from a worker safety standpoint so that needs to be addressed. If you have the same spalling on a light pole foundation, for example, maybe that's not that big of a problem. While it's something that needs to be looked at, it's not something that needs to be addressed or repaired as well as or as soon. In any event, you need to think about what the applications are and what you are using the concrete for. My paper goes into this in a lot more detail.

Mike Franke talked a lot about the process. Again, you need to bear this in mind when you are thinking about designing these things. He talked about people reduction. Staff reduction isn't about getting rid of people; it's about making the organization better. I think increasing quality of the activity is always a part of making the organization better. That is really the theme of what I am trying to get across today.

In terms of this subject again, I have an interesting story that I have had happen to me. Not many consultants want to tell you about the things that don't work well in terms of what the purpose of a structure is. However, I had a young engineer working for me and we were supporting a water tower on the top of an existing industrial building. I had left this project with this young engineer and his job was to design a structure to hold it up. The building bays were 40 by 40. Well, he chose to use two wide flange beams standing 40 feet and set this water tower right in the middle. I don't know how much experience you have with wide flange beams at 40 feet, but they have a lot of flecture in them. The word came back to me after about a month after this thing had been up that the client had some concerns about it. I went up on the roof of this thing and, sure enough, you could take your foot and this thing would just go "boing!" Clearly we had a structure here that had not failed, but it was not meeting all of its intended uses. This young structural engineer said it didn't fail, but I told him that not failing is the minimum requirement of a structural design.

Bear in mind in concrete repair you have a lot of different uses of concrete and there are a lot of different reasons to repair. The level of repair will depend on that.

I think Gene Corley spoke a fair bit about types of repairs and got into that in a more detail so I am going to touch on it just a little bit. One thing that I am sure he emphasized and you cannot overemphasize is to read the directions and surface preparation. I make a comment in this paper that if you are not going to take the time to do the surface preparation right on a

concrete repair, you might as well not do it at all because it isn't going to last. That's all there is to it. It's really important. I heard a story the other day about a maintenance crew that did a concrete repair and it was a two-part system. They didn't even realize that it was a two-part system with an epoxy additive. Well, they didn't have epoxy additive so the repair didn't last. When they got all done, they walked up to their boss and asked what the other can was for. Well, by then it was too late, of course.

In my view, for people who do concrete repair and renovation on any kind of a day-to-day level I don't think you could talk about it without having a good understanding of the types of commercial products that are out there to do the concrete repair and coating. I am not going to go into that because I think Gene Corley did and it's too big of a subject anyway. I am not going to get into the names of suppliers because I would probably violate a conflict of interest code, but there are a number of people who supply these products. It's a matter of understanding what they do and what they won't do. It's kind of a matrix understanding the products and understanding the applications for them. We have one or two product lines that we use. The people that supply this have some good tech service people and we have faith in them. They come in and talk to us about our applications and that's the success to working on concrete as far as I am concerned. It's having a good line of reliable products that will fit things as well as getting good information from the people who make the products.

One other thing I would recommend that you do as a function of your organization is to write specifications for concrete repair and to check your specifications every so often. Time passes quickly and before you know it you have written a specification that is five years old. We had one case where we found out the company who called out the specifications didn't even exist anymore. Fortunately the people would tend to work around that. It's embarrassing and it's not necessary. So if you have standard specifications for this, get them out and talk to the suppliers. For most of these concrete repairs and renovation suppliers, if you give them the specifications they are going to put their input in there. They will at least review them and tell you what is wrong with them and what is right with them. Again, you need to have somebody with a fair bit of credibility.

In summary, the message here is good surface preparation, know the people who make the products, know what the products are and know what the applications are for. I am not going to get into those in great detail.

I am going to talk about some specific applications that we fool around with in the railroad industry. Certainly concrete and cement is subject to deterioration.

This slide is some sort of a parts washing operation. If you look closely at the concrete, it's coming all to pieces. You would expect it to come all to pieces if you are dumping caustic solutions on this. At the outset, we have a bad application for concrete here. It's entirely possible that someone located this parts washing operation in an area where it was not intended to be. There should have been some sort of coating put down for it and you could have prevented this damage. How serious is it? Probably not too serious. It's probably a trip and fall problem if anything. So concrete is very susceptible to corrosion from a lot of chemicals that we use in the railroad industry.

A locomotive washing facility is a common application for concrete. We have one right now that is going to be a problem. We designed and built it last year for a major railroad in the east. I am not going to tell you who it is, but the first letter is N. We had this long discussion about whether we were going to coat the concrete in the wash rack apron. No, we are not going to do that. Well, why not? Because they were are only going to use water to wash these locomotive. How many people out here believe that this wash rack is never going to use anything but water? That is absolutely preposterous. Sooner or later the shop foreman is going to have some FRA problems and he is going to hook some soap up to that and in no time the concrete is going to be coming apart. I take a great personal feeling of loss that I wasn't able to communicate that message to these people, but it happens. It's a case where someone wasn't will-

ing to spend the extra funds and recognize that they were going to have a need there and deal with it at that time. In general, we do a lot of work with these people, and it's not a common problem. They are pretty good about it.

A servicing apron is an interesting concrete application. We do a lot of those. Servicing pits are a real interesting animal to me. One thing about the railroad industry at least from my viewpoint is you seldom see an out and out structural failure. Railroaders are known for building things stout. There is nothing wrong with that. Because of that, you don't have a lot of structural failures. I have seen more, if not failures, serious structural damage in locomotive servicing pits than probably everything else put together. You simply cannot analyze these by taking even dynamic loads of locomotives and building the walls. There is just more to it than that. They need to be built very heavy.

We have our own formulas for how we go about it. Another thing that I have seen in locomotive pits is it has a lot to do with the design of the wall joints and how you put this thing all together. You see a lot of problems with them. Unfortunately, they are really hard to fix. I have not seen a lot, but I have seen more locomotive servicing pits torn out and rebuilt than probably everything put together.

Now the walkways are another application that are almost always overdesigned from a structural standpoint, because all you are going to do is walk on them. But they are subject to deterioration from chemicals and wheeled vehicles, et cetera. So we recommend a hardener sealer on walkways. Some railroads use them and some don't.

This is just a picture of a shop. Some of the more interesting concrete repairs and renovations I have been around are in old shops where this area used to be the compressor room and now we want to make it the locker room or it used to be the locker room and now we want to make it the compressor room, for example. One thing about old railroad concrete is most of it was built real stout and it's amazing the load you can put on those things sometimes.

Again, you need to be careful when you are working around old shops because quite often that concrete is not the same material that you are putting in. Whenever possible, you need to isolate the two in whatever fashion you can.

I am going to finish this with one last story. Railroads get involved in a lot of environmental water bearing structures and one of the things we are seeing more and more are facilities to store or contain hazardous waste from drum solvents and that's usually in larger shops. Do we have any chemical engineers in the room? No? Good. So I can make fun of chemical engineers. It's always a very enjoyable thing to do. We have a project we are working on for a chemical plant in Atlanta. They had a tank farm that they had used for storing some sort of oil, a nonhazardous application, and they wanted to use that tank farm for storing drums of hazardous waste. It's a completely different application. Any leakage rate was going to be essentially unacceptable so you couldn't apply the same kind of standards for design and construction to analyze the structure for one use as you did another. I had one of my chemical engineers and one of their chemical engineers just having a fit about the concrete base. They brought me a drawing of it. The concrete base was 20 by 40 or something like that. The way it was drawn on the paper, it looked like it had been poured in six little sections with no water stops or anything. That just wasn't going to do for what we were doing. As they described it to me, I asked why it was poured in six sections. They said they thought it was because we have these little lines in the middle and they are about half an inch wide and at least deeper than the guy's knife blade. I said they probably got some one by threes and put them there for crack control joints. So we went out there and sure enough that's what it was. But it was amazing that these chemical engineers couldn't figure that out.

The point of the thing is we had a structure that was designed for one purpose that if it had not been that, it would not have been useful at all for the other purposes.

Anyway, that concludes my remarks. Again, I didn't talk too much about diagnostics. I hope you found it a little bit interesting. I would be happy to take any questions and I will start

with one question for you. How many of you in the railroad industry have programs that analyze how much you spend on repair and renovation in a given year? Do you know what that number is? Hundreds of thousands? Millions? My recommendation for your homework assignment is to go back and take a look at that number and take a look at how much could have been saved if the structure had been put together right to begin with. Give some thought to creating a program that does that – a management task that allows you to spend a little more money looking at the design and construction so you don't have to do the repair in the first place.

Thank you. (Applause)

Mr. Carter: Thank you very much, Mike, for an excellent presentation.

Mr. Lileikis: Our next presentation is entitled, CP's Diesel House Consolidation in the Twin Cities. The presenters are Steve Hill, manager structures, CP Rail, and Bill Komala, supervising architect, Ragnar Benson, Inc.

Steve Hill began his career in 1972 as a section laborer for the Union Pacific, putting his Bachelor's degree in History to good use. He then moved on to a survey crew and finished a degree in civil engineering in 1977 from the University of Kansas. Steven then spent two years at ICG.

In 1980 he hired on with the Soo Line as office engineer, transferring to Chicago in 1987 as assistant regional engineer just after receiving his MBA from the College of St. Thomas. Steve then became assistant division manager in 1991. He returned to Minneapolis in 1994 as manager of bridge and structure construction. After the recent reorganization earlier this year, his title was changed to manager structures. Steve is a registered professional engineer, member of the B&B Association, past president of the Roadmasters Association, and member of AREA.

Bill Komala is supervisory architect, designs for Ragnar Benson. He has had a broad engineering background beginning as an electrical draftsman for G.A. Rafel. Bill served in the U.S. Army as a specialist in assisting field inspection of bridges and roads during the Viet Nam era. He began employment at Ragnar Benson as a mechanical draftsman in November 1966 after an honorable discharge from the service. Since that time, he has detailed various mechanical, architectural and electrical designs.

In 1971, Bill became code specialist in charge of Construction Permitting. In 1977 he designed and secured preliminary approvals for the Bell System Center West Training facilities. In 1983, he was project captain for the civil design of the first midwest intermodal terminal for CSX. Bill has worked for various clients including CSX, CP Rail, EMD, Metra, Union Station and numerous office buildings.

I will now turn the podium over to Steve Hill and he will introduce his presentation.

CP'S DIESEL HOUSE CONSOLIDATION IN THE TWIN CITIES

Steve Hill

Manager Structures
CP Rail

and

Bill Komala

Supervising Architect
Ragnar Benson, Inc.

Mr. Hill: I will be doing the introduction portion or a little bit of background for the St. Paul diesel house renovation project. Bill Komala, supervising architect from Ragnar Benson, will be talking in detail about it.

The Canadian Pacific Railroad has had a long history. Since the early 1800s, its pioneers have literally moved mountains to accomplish the task of linking Canada from seacoast to seacoast. They have had a financial interest in the original Soo Line since the earliest days.

The Milwaukee Road's St. Paul yard was originally started when the St. Paul and Chicago Railway reached the Twin Cities in the 1870s. The original roundhouse was built at the turn of the century.

The facility at Shoreham, located in north Minneapolis, was from the original Soo Line, the Minneapolis, St. Paul and Sault St. Marie. Development started here in 1886. Because of its central location on the system and proximity to the major metropolitan area, it quickly became the major yard and focal point on the system for car repair and construction, locomotive repair and construction, passenger service and so on.

When the Soo acquired the Wisconsin Central by lease in 1909, the car repair work was concentrated at their major facility in Fon du Lac, Wisconsin. Shoreham still handled all the heavy locomotive repair, components rebuilding, passenger car construction, was the central stores location, and also the largest freight yard for the system.

After the 1985 acquisition of the Milwaukee Road, Shoreham remained the major maintenance facility for locomotives. The Milwaukee St. Paul yard took over the major yard classifications work with their larger facility and the yard at Shoreham was eventually converted to container loading.

St. Paul's importance really grew in the 1950s when the Milwaukee Road constructed a modern hump classification yard at the same time similar yards were constructed in Milwaukee and Bensenville. The maintenance facilities evolved from the need to have locomotives ready when the trains were.

Mr. Komala: In 1985, the old Milwaukee Road was acquired by the Soo Line and wherever possible, the Soo combined routes and traffic handling of the two carriers. By 1990, the combined company began an efficiency program that had downsized the work force by 3,000 employees and 2,000 miles of track. The consolidation also resulted in maintenance work being done at fewer facilities.

The Canadian Pacific was the majority stockholder of the Soo Line. In 1990 the Canadian Pacific bought out the minority interests and the Soo Line and Milwaukee Road became a wholly owned subsidiary. As a subsidiary of the Canadian Pacific Railway, the Soo Line offers

a link to the Midwest with rail connections extending deep into the heartland to rail hubs like Chicago, Louisville, and Kansas City. While the Soo remains a separate US corporation, its operations are jointly managed with those of the Canadian Pacific in Canada. As a result, many customers and the general public view the current enterprise as a single company doing business in both countries.

This fact has emphasized the need for more efficient ways of doing business as a larger intercontinental operation rather than stand-alone rail systems. For example, the combination enabled Soo to make more extensive use of Canadian Pacific's data base via existing computer systems and E-mail type facilities. The use of those tools now allowed Soo Line and the Canadian Pacific to share assets in track maintenance and freight car supply between Canada and the US thereby maximizing their efficiencies. Through the consolidation of various personnel and departments, the new operations reduced duplicated efforts and cross-departmental paperwork.

The design and property management departments of both railroads were minimized to trim payrolls and outside engineers would be used for work previously done by internal forces. This decision impacted some of the planning already in progress but the long-term benefits will be seen from future expenditures being minimized.

Through the use of modern computer systems already in place, the staff of both railways are in direct daily contact using E-mail type facilities to transfer information. These systems now allow the Canadian Pacific to establish data base input.

The benefits of documentation of locomotives service, of fueling operations, and of equipment utilization permit planning for future improvement. Additional facility surveys looked for outdated methods of documenting equipment maintenance records and billing procedures. The focus was put on looking for areas of costs savings. Attention was given to using personnel and equipment more effectively than ever before.

The Canadian Pacific having trimmed their costs through the first wave of reorganization next sought improvements through facility upgrades. Each yard and service center was studied. The results of the facility surveys prompted planning based on data gathered and on employee suggestions.

The older shops became candidates for upgrade or replacement. More up-to-date methods were examined and the necessary equipment purchased to allow better use of personnel. Some repairs were subcontracted to outside vendors allowing better use of staff for the work to be done. The types of maintenance rendered by in-house staff provided just-in-time fixes.

Record keeping now plays an important part of engine utilization. By logging engine maintenance, important servicing can be scheduled reducing unexpected downtime and improving the reliability of equipment.

The area of importance to our discussion today is equipment maintenance – specifically the 1,700 diesel electric locomotives that are repaired system wide. For the past several years, CP has been trimming costs by closing and consolidating work at fewer shops across the system. Shifting rail traffic patterns and new technologies in today's equipment have demanded changes in how maintenance is done and where.

The bulk of CP's heavy maintenance to locomotives is being relocated where the heaviest work patterns exist today and at fewer locations. St. Paul is a hub for train activity in the Midwest and was chosen as the point for centralizing locomotive maintenance. The Soo Line currently owns two locomotive repairs facilities in the Twin Cities – one from the former Soo and the other from the former Milwaukee Road. Located just 10 miles apart, these shops duplicate one another and are costly to maintain. A decision to close the Minneapolis facility and expand at St. Paul came last year as a means of minimizing costs and further improving efficiencies.

At the St. Paul shops, the maintenance of way, bridge and buildings, mechanics, and fueling operations share a total facility. Attention was given to study the various types of services

provided. Scheduled preventative maintenance includes oil changes, lube and engine checks, components change out, traction motor repair, wheel truing, and static test work, in the 48,000 square foot shops. All engine work is handled in four track bays capable of spotting two to four locomotives. In other words, all the ongoing care an upscale auto dealer would do to maintain your car in top condition.

The outside fueling operation utilize three track approaches permitting four locomotives to fuel simultaneously.

The St. Paul yards offered a new unique potential for Canadian Pacific's future plans. The analyzing of equipment and staff activities made the railroad aware of what is needed to improve operations. The analysis produced the beginning of the plan for the 1996 Expansion Program. The potential operational improvements would lead to benefits in engine servicing and a decrease in turnover time for work needed. By adding two track bays, eight more service positions and 60 percent more space would be available.

The centralized storage of parts in the stores department for the car shop and the Diesel repair operations would also improve service turnover time. The stores department was studied for potential upgrade as well. With service facilities getting attention, the employees took the opportunity to suggest improved T & E areas. Shop mechanics also felt their needs should be known. Suggestions led to consideration of new facilities which would open up old areas for equipment and training space. By eliminating outdated toilets and locker rooms, more storage could be provided for parts. The space also allowed for a new communication repair shop and employee training room with upgraded toilets.

Site Development

After needs were assessed internally, the staff architect combined the feedback from various operating entities and conducted a site utilization plan. The preliminary plan concept included an architectural outline depicting ways of meeting space needs best using the existing building configuration and site. The conceptual considerations for the shop location included proximity to the main line, tools and equipment availability with the side benefit of improved parking.

Trainmen and enginemen facilities would be disrupted by the initial concept so their facility was brought into the scope of the redevelopment. Site access by employees was a limiting factor in the site design

The consideration given to the conceptual plans for the Welfare improvement led to consolidation of the present locker/lunchroom into an expanded locker and lunchroom with improved shower facilities and new toilet facilities.

The concept was now expanding to improve sewers, water distribution, electrical, and other site utilities. The expected potential for more servicing at the St. Paul facility would permit the closing of the Shoreham yards. Many of the service operations could be handled in St. Paul, and after the expansion, would be more effective.

The back shop remodeling would lead to improvements in their ability to provide services now being done at Shoreham. Program development and the implementation of a more designed (inclusive) scope outline led to the selection of an outside engineering firm to design the various elements of this expansion.

A field trip was arranged to view the Winnipeg shop facility as a model for the new diesel shop. The engineer was asked to study current operations looking for improvements which could be incorporated into the concept. He was asked to define equipment and services to be used and anticipate future problems and solutions.

An intense expansion of the scope document was needed to provide the information to include all the items sought by this expansion. The realization that permitting agencies would impact the desired schedule of the expansion led to a focus on obtaining city approval for construction in the flood plain as a conditional use. The timing was delayed by a need to make public the plans for closing Shoreham and consolidate the staff of the two facilities.

Construction Activities

The timing of these studies was intense. Site preparation and coordination became an enormous concern. A meeting was necessary with the owner/users to advise all construction activities. To maintain continuing operation of the site, it was necessary to develop a team approach to problem solving. The introductory meeting allowed everyone to get to know the players and establish the routine of weekly problem solving meetings.

This initial meeting was used to present an activities schedule which defined site safety during ongoing owner operations, the methods for construction deliveries, and construction parking and storage. Decisions were made regarding use of owners facilities, toilets, phones, and meeting space.

Building construction during train operations meant maintaining safe movement of equipment and personnel. This necessitated staging of daily work, proper clean up and planning, and daily communication with key personnel from the railroad.

The effectiveness of teamwork in problem solving requires immediate contact with effective people. Staying in touch about the problem being solved leads to an awareness of the site progress and decisions affecting the outcome.

The initial state of the project can be seen by these photographs of the dike area. The earthen berm will be replaced by a concrete retaining wall which will allow more space for the new diesel shop. The existing storage facility will be expanded by a Welfare Addition. This new space will include locker and lunchroom areas and will replace the existing toilets with modern facilities.

New utility pipes have been installed and the oil separator has been replaced to improve the site drainage and sewer services. Site remediation during construction was arranged by Remediation Technologies who oversaw environmental safety for the owner and contractors. Clean backfill replaced poor soils and the installation of over 500 piles produced a stable base for the 24,000 square foot building construction. These timber piles ranged from 38 feet to 45 feet in length and were clustered under the building columns for average individual loadings of 35 tons each. More than 40 steel piles were also installed for 45 ton capacity at key locations. Later they are cut off to the proper elevation and a continuous pile cap of concrete is poured to construct the building foundation.

The steel building frame and insulated metal walls forming the outer envelope were quickly assembled while interior concrete pours continued to produce the track service pits. Locomotives stand idling alongside of building erection crews as the walls of the 340 foot long diesel shop were attached. Inside, the lower level of the shop floor was prepared for concrete as the roofing and insulation were being attached in another area of the building.

The owner has done a great deal to allow the contractor access for the timely construction of such a large building in the heart of an operating yard. To date, the site improvements are on schedule with minimal surprises due to good planning and team cooperation. The changes that have occurred during construction reflect a better understanding of building and site uses.

Approach tracks have been laid by the railroad personnel while interior rails are aligned by the construction forces. The end wall of the shop was left open until the delivery of the key equipment was completed. With the installations of the two 10-ton bridge cranes spanning 60 feet across the building, the siding continued to complete the building envelope.

Work now continues on the drip pans for the engine start up area and the existing back shop improvements and additions. Site grading and paving are scheduled for the fall with completion set for year end.

Future Plans For This Site

A new yard office is currently in the planning stages. This facility was under consideration as part of the original expansion plan, but was delayed to allow the owner to focus on the total site development.

A new section building and other improvements will be undertaken in the future to make this site ready for the next hundred years of railroad involvement in the future of America.

Mr. Lileikis: Thank you, gentlemen. Next are the standing committee reports. The first is education by Jimmy Neece, supervisor facilities maintenance, CSX.

Standing Committee Report

Education

Chairman: J. Neece, Supvr Facilities Mtce., CSX

Mr. Neece: I'm proud to announce the first Bridge Repair Seminar held in the Chicago was a success. We had 17 attendees at the seminar and all feedback was positive. Plans are underway for another Bridge Repair Seminar to be held in Atlanta in February. We'll be sending brochures out around the first of December.

The Bridge Inspection Seminar held once again in Denver was also a success. We had 60 people there and the room was crowded. Next year it definitely will be limited to 50. Those brochures announcing the seminar will be mailed in February.

Registration fees for both seminars will remain the same; $375 for members and $475 for non-members. You do have to be a member by January 1 to take advantage of the member rate. We hope to see you all at both seminars!

Mr. Lileikis: Thank you, Jimmy. John Horney will now give the scholarship report. John.

Standing Committee Report

Scholarships

Chairman: J. Horney, Sr. Rail Mgr - Structures, Carter Burgess

Mr. Horney: I'm happy to report that the B&B Association awarded three scholarships for the 1996 school term. The first was a renewal of a 1995 scholarship awarded to Ms. Sarah Dennis. Sarah is the daughter of Bill Dennis of the Iowa Interstate Railroad.

The second scholarship award went to Mardene Bartholomew, the daughter of Dale Bartholomew of Sverdrup Civil in Bellevue, Washington.

The third scholarship was awarded to Jamie Hill, the son of Gary Hill of Union Pacific, Omaha, Nebraska.

Mr. Lileikis: Thank you, John. We'll recess for lunch and return here at 1:15.

(Recess)

MARDENE BARTHOLOMEW

JAMIE HILL

BRIDGE AND BUILDING SESSION

Tuesday Afternoon

Mr. Lileikis: Welcome back. Mr. Franz will introduce the first committee report this afternoon.

Mr. Franz: The next committee report is Bridge Failures, Recent and Past. Lessons for the Future. The co-chairmen are Richard Bennett of the University of Tennessee and Thomas Skinner of HNTB.

Committee Report

BRIDGE FAILURES, RECENT AND PAST LESSONS FOR THE FUTURE

Special Subject #4

Chairmen: R. Bennett, The University of Tennessee
T. Skinner, HNTB Corporation

Committee Members: G. Barksdale, American Inland Divers
R. Calhoun, CTE Engineers
J. Cliff, Spandeck
R. Flanagan, Lockheed Martin Energy Systems, Inc.
C. Hague, Alfred Benesch & Co.
K. Jennison, Burlington Northern - Sante Fe
N. Marianos, Modjeski & Masters
L. Muir, Cives Steel (former grad student, UT)
V. Sharma, Sharma & Assoc.
D. Sorgenfrei, Modjeski & Masters

INTRODUCTION

The history of the railroad industry in this country is an exciting and varied one, with great advances occurring at a terrific and at times terrifying pace. From the invention of Englishman George Stephenson's Rocket, in 1829, and American Robert L Stevens' T-section rails on wood ties in the 1830s, to the construction of the Transcontinental Railroad completed in 1869, to the promise of new high-speed rail systems, the railroad has pulled in its wake many of the great achievements of the world, both engineering and financial.

Of course, advances which occur over such a relatively short period of time are rarely accomplished without some painful failures along the way. This is true of the railroads. As the full monetary potential of the railroads began to be realized, many with less than honorable intentions flocked to the new industry. Shoddy construction and labor practices which amounted to usury pockmarked the railroads' history, causing many catastrophic failures of locomotives, bridges, railroads, and the social fabric in general. Even when pains were taken to provide safe and efficient railroads, designers were often venturing into virgin territory and pushing the limits of their knowledge and skills to the breaking point.

No one could have estimated the rate at which the railroads were to grow during those first 100 years of their existence. During the late 1800s, locomotive weight was rapidly increasing, with the weight being doubled between 1870 and 1890. Some reports indicate that one out of every four bridges that were built failed (Gies, 1963). But those were different times. People were more daring and lives hung in a more precarious balance on nearly every front. Railroad bridge failures were more or less accepted as a normal part of life. Railroad travel was, at the time, a dangerous venture, as evidenced by the prevalence of folk songs celebrating the great train wrecks of the time. American railway men even fought the installation of telegraph lines to control rail traffic as an unnecessary expense.

Such dangers could only be tolerated for so long though. The Ashtabula bridge collapse in 1876, which killed up to 90 people, proved to be a watershed event in the history of railway bridges. The Ashtabula failure forced both the public and engineers to take a closer look at the bridges, which were carrying an ever-increasing number of people across the country. This did not mean an end to bridge failures; over 200 bridges failed in the decade after the Ashtabula failure (Gies, 1963). The Ashtabula failure, however, moved the bridge failure from the realm of "natural disaster" to human error. From that point on an effort to uncover the causes of individual bridge failures was at least attempted, so that future catastrophes might be prevented.

So the question becomes, what causes a bridge, or for that matter, any other structure to fail? Stated simply, it is a failure to achieve an acceptable balance. Engineering is after all in its purest form a balancing act. Equilibrium is attained through a balancing of forces. Economy, aesthetics, and performance all must be weighed and an acceptable balance found for a design to be considered successful. Many times in great undertakings, great egos and great ideas must be balanced. Innovation must be tempered with established practice. A healthy respect and knowledge of past works must always be present if the engineer is to challenge and conquer the future. Engineering is an art as much as a science, and the engineer must take a holistic approach to design, for the failure to balance any of the variables involved in a project could lead to unacceptable performance, financial disappointments, or catastrophic failure.

This report examines bridge failures, and the lessons learned from the failures. The report begins with some introductory remarks on defining a bridge failure, types of lessons learned, and a statistical analysis of bridge failures. This is followed by an examination of some of the famous historical failures. A review of modern day failures and bridge problem areas is then given. The overall theme is that we have moved from collapse to component failures.

DEFINITION OF BRIDGE FAILURE

What first comes to mind when one says "bridge failure" is the catastrophic type failure with an image of a bridge in pieces in some body of water or a train plunging off the end of the bridge. Although these occasionally happen, they are quite rare. Quite simply, a failure is the lack of a bridge to meet some desired performance goal. Engineers speak in terms of limit states. These can be strength limit states or serviceability limit states. When a strength limit state is exceeded, it is desirable to have redundancy and/or ductility in the structure, so that collapse will not be imminent. Bridges in general have a surprising amount of redundancy, and there are many cases of "non-redundant" bridges functioning after a member failure.

A bridge does not have to "fail" for the strength limit state to be exceeded. If the rating of a bridge is sufficiently low so that traffic is restricted, the bridge has "failed." This is often referred to as being obsolete. In general, railroads have been quite insightful into future traffic demands when designing and constructing bridges, so that the occurrence of "failure" due to obsolescence is much more infrequent than with highway bridges.

A serviceability limit state is often more difficult to define. An example of a serviceability limit state would be excessive deflection. Although it is intuitively obvious that there should not be excessive deflection of a bridge, determining quantitatively what is excessive deflection is difficult. For a railroad bridge, it might be when the track fails to meet the FRA standards

for the class of track. Thus, the exceedance of a serviceability limit may still allow trains to cross the bridge, but at a restricted speed.

Finally, there is also the economic limit state. A bridge must support sufficient revenue traffic to justify its cost. Many miles of track have been abandoned simply because the bridges would be too expensive to maintain or replace. Essentially we have an economic failure. Engineers continually strive to improve bridges through new designs and materials to eliminate economic failures.

This report focuses primarily on the bridge and component failures from the strength limit state being exceeded. Although these are often considered disasters from the viewpoint of the involved persons, there is often much to be learned. Petroski (1982) has developed a thesis on the role of failure in successful design, which provides quite interesting reading.

LESSONS LEARNED FROM BRIDGE FAILURES

Bridge failures provide lessons learned in both a specific and general sense. There is the need for thorough and proper documentation after a bridge failure so that the valuable specific lessons for similar type bridges can be learned. Unfortunately, with the litigious society and clients often having a limited interest in the professional lessons that can be learned, information on bridge failures does not make it to the professional literature. Hanson (1984) states "Unfortunately, investigations are too frequently only carried to the point that they serve the interests of the client. It is important that the lessons learned from failure investigations be made available professionally. Investigators should be encouraged to present their conclusions in public forums or in technical papers, where they are subject to peer review." It is important that the lessons learned from a bridge failure be widely disseminated to the profession in a timely and complete manner.

Smith (1976) calls for a regular policy of the prompt and thorough technical reporting on bridge failures. He bemoans the lack of consistency, stating that "one failure of importance to engineers is left without a thorough published report; another is given the full treatment, though the cause is immediately obvious." Although there is the need for thorough reporting, caution needs to be exercised in examining a bridge failure. What appears to be immediately obvious is not always necessarily so.

By studying many bridge failures, certain patterns emerge. This provides general lessons with regard to the conduct of the bridge engineering and inspection community. It is important that these general lessons not be overlooked. Thus, it is important to study such failures as the Tacoma Narrows, even though there are not any suspension railroad bridges in the United States.

This report will examine some specific historical bridge failures, and the lessons learned from those failures. The report will also give a summary of current bridge problem areas. The report also considers some general issues, and draws some general conclusions with regard to bridge failures. It is important for the profession to step back and look at itself from time to time.

STATISTICAL ANALYSES OF BRIDGE FAILURES

A few studies have been performed to examine from a statistical point of view the causes and frequency of bridge failures. These studies indicate some of the prime causes of bridge failures.

One of the earliest statistical reports on bridge failures was given by Cooper (1889). The descriptions of the failures are quite brief, but are summarized in the following table.

Cause of Failure	Data Set 1		Data Set 2	
	Number	%	Number	%
Knocked down by derailments	57	23	60	23
"Square falls"	30	12	34	13
Failing during replacement/repair	5	2	8	3
Carried away by floods			39	15
Wood burns			27	10
Uncertain, unclassified, or unknown	159	63	97	36
TOTAL	251		265	

Smith (1976) examined 143 bridge failures between 1847 and 1975. A summary of his findings is given in the following table. Nineteen of the bridges Smith classified as 'unsuitable or defective permanent material' were brittle fractures. Ten of the bridges classified as 'overload or accident' were ship or barge impacts. Twenty-three of the failures, or 16%, occurred during construction.

Cause of Failure	Number	%
Flood and foundation movement	70	49
Unsuitable or defective Permanent material	22	15
Overload or accident	14	10
Inadequate or unsuitable Temporary works	12	8
Earthquake	11	8
Inadequate design in permanent Material	5	3
Wind	4	3
Fatigue	4	3
Corrosion	1	1
TOTAL	143	

Hanson (1984) discussed ten recent major bridge failures, with all but one being highway bridges. Three of the failures were during construction, and all of these were concrete structures. The other seven failures were during the service life of the structures, and these were all steel structures. Hanson suggests that this is "indicative of an underlying problem with design and construction practices that needs attention by bridge engineers."

An investigation of Federal Railroad Administration (FRA) accident reports from 1982-1994 resulted in the following data. Some of the cases reported were not "bridge failures" as such, but were derailments.

Cause of Failure	Number	%	Comment
Scour	13	17	
Bridge approach	11	15	Primarily just caused derailment
Fire	10	13	Several caused by train; one by grinding
Moveable bridges	8	11	
Vehicle or vessel hit bridge	7	9	
Deterioration	6	8	Includes bridge timbers or ties
Derailment	4	5	
Improper repair or maintenance	4	5	
Shifted loads	2	3	
Ice flow on river	1	1	
Not discernable	9	12	7 were collapses
TOTAL	75		

One of the most thorough statistical studies on railroad bridge failures is reported by Byers (1985). He examined ten years of bridge records for a segment of railway covering approximately 5,500 route miles. Some of Byers findings are summarized in the following table.

Type of Damage	Statistics	Comment
Derailment damage	10 out of 4200 bridges	8 caused mechanical damage; 2 caused fire damage; 9 occurred at some distance from the bridge
High load damage at underpasses	26 out of 250 underpasses	
Shifted load damage to through truss	10 incidents involving 13 out of 55 spans	Several through girders also struck, but damage not serious enough to cause operational restrictions
High-water damage to timber trestles	6 out of 3355	Most related to relatively shallow pile penetration or heavy scour of noncohesive stream beds
Fire damage to timber trestles	12 out of 3355	

Byers (1985) summarized his findings by calculating lifetime probabilities for various types of damage, as reproduced in the following table. He concludes that for a typical bridge life of 75 years, the probability of serious damage from accident, fire or flood is about 12%.

Type of Damage	Probability of Damage		
	Assumed Life of Bridge		
	50 yr	75 yr	100 yr
Derailment damage to any bridge	0.0095	0.014	0.019
High load damage to underpass	0.52	0.78	>0.99
Shifted load damage to through truss	>0.99	>0.99	>0.99
High-water damage to trestle	0.014	0.020	0.027
Fire damage to timber trestle of any type	0.018	0.027	0.036

Although the categories vary from study to study, there are some definite patterns. It appears that the two major causes of bridge failure are scour and impact. Impact can be in the form of a vehicle or ship collision, shifted loads, or derailed cars. Over 100 years ago, Cooper (1888) recognized the problem with impact, stating that "bridge designers or builders have lit-

tle voice in methods to be employed for guarding or protecting their bridge." Things have not changed a whole lot.

Another significant cause of bridge failures are construction, repair, and maintenance of bridges. Timber continues to remain vulnerable to fires. Bridge approaches are almost as important as the bridges themselves. In terms of collapses from structural deficiencies, there are relatively few failures, although these often receive significant press.

An interesting study on the causes of structural accidents was conducted by Sibly and Walker (1977). Starting with the Dee bridge failure in England in 1847, they show a pattern of a major bridge failure about every 30 years. The Dee bridge was a so-called truss girder bridge, and exceeded the length of previous bridges of this type. It essentially failed through lateral-torsional buckling, which was unknown at the time. The next failure discussed by Sibly and Walker is the Tay bridge failure in 1879 due to wind. Also around this time was the Ashtabula bridge failure in 1876. They follow with the Quebec bridge in 1907, and Tacoma Narrows in 1940. Projecting the approximate 30 year cycle forward would indicate a failure in 1970. Sibly and Walker cite the failure of several steel box girders in Australia. There was also the Pt. Pleasant failure in 1967. Projecting the cycle still further forward would indicate a major failure in the next several years, or about the turn of the century. Some have suggested that this failure will be a cable stay structure.

The question is raised as to why the period of thirty years between major bridge failures. Several reasons could be postulated. One is a communication gap between one generation of engineers and the next. This is certainly plausible, and leads to the lesson of the need to learn from history. Another explanation relates to engineers pushing the design limit further and further until finally we reach beyond our limits.

The Tacoma Narrows failure provides an interesting study in the pattern of bridge failures. It marks the shift from the failures being railroad bridges to being highway bridges. More importantly, it marks a repetition in history. The Tacoma Narrows bridge was not the first suspension bridge to fail; there was a long standing record of flexible suspension bridges being plagued by damaging undulations (Petroski, 1995). There were also a number of sources that warned that some aspects of suspension bridge behavior were not fully understood.

In 1836 the Brighton Chain Pier, a multispan suspension bridge, collapsed into the sea after a documented history of deck oscillations. Between 1837 and 1839 Thomas Telford's Menai Strait Suspension Bridge, which was said to have heaved as much as 16 feet in heavy winds, was repeatedly stiffened and in essence rebuilt. In 1854, the Wheeling Suspension Bridge across the Ohio River fell due to wind damage. In 1860, Ignaz von Mitis' suspension bridge over the Danube Canal, which was the first bridge to incorporate steel in its construction, was dismantled and replaced because it vibrated excessively and swung wildly in the wind. At least some of these cases were most likely known by the designers of the Tacoma Narrows Bridge, but the designers felt that new methods of analysis, mainly deflection theory, which had been devised in the early twentieth century would prevent the more modern bridges from experiencing the same sort of problems. This belief was supported by the performance of more contemporary and impressive bridges.

The Roeblings' Niagara Gorge and Brooklyn Bridges had not suffered the same sort of problems that had plagued their predecessors. More contemporary suspension bridges, such as the Golden Gate Bridge, also had far fewer and less severe problems than bridges of the past. It is true that during the opening ceremonies for the George Washington Bridge, the marching of soldiers in the parade caused noticeable vibrations in the flexible span. In 1938, the Golden Gate Bridge was reported to have deflected vertically in a wavelike manner during a windstorm. But these were not considered to be serious problems, and they certainly did not warrant any doubt concerning the superior bridge design methods of the time. On the contrary, this string of successes had only caused bridge engineers to feel that they understood the behavior of suspension bridges far better than they actually did. What they did not realize was that the

success of the more recent bridges had been as much a result of heavier loads and longer spans, which caused a stiffening of the deck and in turn less flexibility, as it was due to better engineering knowledge. This fact was lost to many engineers at the time, because they felt that they were part of a new age in engineering, in which mathematics and science would dominate a field which had previously been governed by model building and tenuous empirical knowledge.

The use of "deflection theory" in designing suspension bridges allowed decks that, contrary to intuitive thought, became less stiff as the dead weight was increased. As a result, longer bridges would actually be designed to allow more flexibility than shorter spans. Engineers took pride in producing structures with extremely flexible decks, since such decks could be constructed with considerable savings. As a matter of fact, Ammann, who designed the George Washington Bridge, criticized his contemporaries for utilizing overly stiff decks and envisioned the bridge of the future to be much more like "the early English type suspension bridge" with an unstiffened floor suspended from the cables. This thinking was consistent with the deflection theory approach. However, there are certainly dangers involved with using failed bridges as models for more daring engineering bridge designs. It was believed, in accordance with deflection theory, that longer spans would utilize heavier cables, which would compensate for a more flexible deck. Of course this approach neglected all but static loads. Dynamic behavior of the structure was never considered. It never had been in the design of suspension bridges.

There were warning voices both before and during the design and construction of the Tacoma Narrows Bridge. Theodore L. Condron, who was the advisory engineer to the Reconstruction Finance Corporation, which was to finance the bridge, expressed many concerns about the proposed design for the Tacoma Narrows Bridge. He was most troubled by the narrowness and flexibility of the bridge's deck. He prepared a chart which showed that the span-to-width ratio of the Tacoma Narrows Bridge was 1:72; the next narrowest bridge was the Golden Gate Bridge with a ratio of 1:46.7. Condron strongly recommended that the bridge deck be widened to 52 feet, though he buffered his recommendation by stating that he was not as qualified as the designers in the area of suspension bridges. *The Engineering News-Record* had also published in 1934 and 1935 a series of eight articles, which discussed the aerodynamic effects of wind forces on structures and warned that much was still unknown about such behavior.

Several general lessons can be learned from the Tacoma Narrows bridge. The first is the importance of history. The old saying that "those who do not know history are bound to repeat it" applies to bridges. There had been a rash of suspension bridge failures approximately 100 years before the Tacoma Narrows that gave a clue with respect to wind problems. Another lesson is that instead of proceeding in a cautious manner, a monumental leap of faith was made, going from the 1:46.7 span-to-width ratio of the Golden Gate Bridge to the 1:72 span-to-width ratio of the Tacoma Narrows. If the 1:53.8 ratio proposed by Condron had been used, the problems associated with the Tacoma Narrows Bridge might have been less severe and easily corrected. It may have still served as a warning but in a much less dramatic fashion. These lessons learned from the Tacoma Narrows failure are especially relevant today. Like in the earlier part of the twentieth century, we seem to be at the cusp of a new age in engineering when the drudgery of hand calculations and sloppy approximations is being replaced by the speed and accuracy of the computer. Perhaps caution and old-fashioned common sense are needed now more than ever.

HISTORICAL BRIDGE FAILURES

Ashtabula Bridge, 1876

There have been several notable failures resulting from welded bridges, particularly starting in the seventies. Similar to the Tacoma Narrows bridge, there was actually warning of the problems with fatigue and fracture approximately 100 years earlier, that being in the Ashtabula

bridge. Since the failure of the Ashtabula bridge on December 29, 1876 remains a watershed in the history of bridge design, this failure will be examined, and then its relation to present bridges discussed.

The exact death count from the Ashtabula bridge failure remains uncertain, but at least eighty people were killed, and it led to the suicide of two others. The popular literature still suggests that the failure was due to a car derailing shortly before it reached the bridge, and the derailed car causing the floor beams to fail, which led to the entire collapse (Cook, 1987; Petroski, 1995). A detailed engineering analysis of this failure was recently performed (Gasparini and Fields, 1993), which showed that the failure was initiated by a combination of fatigue and brittle fracture.

The Ashtabula bridge was a deck Howe truss with 14 - 11 foot long by 20 foot deep panels. It was constructed by Amasa Stone of the Cleveland, Painesville and Ashtabula Railroad. Stone had significant experience with Howe trusses, testifying at the inquiry that he had built 10 to 15 miles of Howe bridges. Stone was also the brother-in-law of William Howe, and was one of the developers of the Howe truss. Although most of the Howe trusses used timber, Stone decided to build the Ashtabula bridge completely of iron. Perhaps this was because he wanted to innovate, or perhaps it was because his brother was a partner in the rolling mill that was to provide the I beams. Although Stone had constructed a few all iron bridges, this was not the norm. In fact, Eads had opted for his arch design for the St. Louis Bridge partly because he feared that failure could occur in iron repeatedly loaded in tension, such as occurred in suspension bridges.

Construction of the bridge took place between 1863 and 1865. Although there were some problems with the design and construction, the bridge was successfully tested with three engines, and had been in service for ten years at the time of the collapse. Of significance to the collapse was that there was a cast iron angle block at the top chord connection with a lug that the top chord bore upon.

Several investigations were conducted into the failure. The Ohio legislature appointed an investigative committee. The conclusion of the committee was "The failure was not due to any defective quality in the iron. It was not owing to the sudden effect of intense cold, for failure occurred by bending, and not be breaking. It was not the result of a weakness gradually developed after the erection of the bridge. It was due simply to the fact that it was not constructed in accordance with certain well established engineering principles (Report of the Joint Committee, as quoted in Gasparini and Fields, 1993)." Essentially the blame was laid on the railway company. This led to the suicide of the chief engineer of the railroad, and later to the suicide of Amasa Stone.

Another investigation was performed by an engineer on behalf of the coroner's jury in Ashtabula. He concluded that the failure resulted from the buckling outward of the three I beams in the top chord. A third investigation was conducted by Charles MacDonald, probably on the behalf of ASCE. MacDonald was the only one to note the existence of a flaw in one of the lugs that supported the top chord. He noted that a lug had broken off where the failure initiated, and the fracture disclosed an air hole of approximately half the cross-section. MacDonald defended Stone by saying that "the Ashtabula bridge was the result of an honest effort to improve the bridge practice of the country, undertaken by a man whose experience in wooden bridges warranted him in making the attempt."

Essentially, the failure was the result of a flaw in the cast iron, partly due to the transition from the main body to the lug. With time, fatigue probably caused the flaw to grow, until finally there was a brittle fracture. The low temperature at the time of failure probably contributed to the brittle fracture. In Cooper's 1888 Specification for bridge design, the use of cast iron was forbidden. However, the specification made no mention of fatigue. At the time of the Ashtabula bridge construction, there were a few pioneering studies in fatigue in Europe as the result of failures of iron railway axles. The effects of stress intensities and brittle fracture were completely unknown at the time.

It thus appears that the failure of the Ashtabula bridge was the result of something that was not known at the time. Gasparini and Fields (1993) conclude that had the flaw not been in the lug, the bridge would have probably served a full life. It is unfortunate that the true cause of failure was not identified by most of the investigation parties, and that the blame was laid on a man that was probably qualified to construct a pioneering type bridge.

One of the general lessons to be learned from the Ashtabula bridge is the importance of identifying the true cause of failure. The derailment myth still exists today, and has meant the true cause of failure is not widely known. The other lesson relates to the specific cause of failure. Primarily as the result of the Ashtabula failure, cast iron was not used for bridge members. However, we developed a process not too dissimilar from casting, but called it welding. In both casting and welding, the metal is heated to a molten state, than allowed to cool with no further forming. The Ashtabula bridge indicated that this can be a dangerous situation for bridges.

Several examples exist of bridges in which weld flaws led to bridge failures. The King's Bridge in Melbourne, Australia failed on July 11, 1962, after only 15 months in service (Madison and Irwin, 1971). The bridge was a steel four-girder deck span that failed on a cold winter morning (40 F). Concrete sidewalls prevented complete collapse, and the bridge span fell only about 18" preventing a major disaster. The bridge failed through girder fractures at the end of welded cover plates. The combined effect of a stress concentration, restricted weldability of the steel, and improper welding procedures resulted in cracks at the toe of the transverse welds of the cover plates. There were shrinkage cracks in over half of the over 100 girders fabricated for the bridge. In the failed span, these cracks had penetrated the flange. One of the interior girders had cracked to within a few inches of the top flange in the previous winter. During the next twelve months, the crack in the other interior girder grew due to fatigue. Finally, the critical combination of temperature, crack length, and load were reached which caused the second girder to fail, with the others rapidly following. Only the top flange of one outside girder remained intact. Madison and Irwin (1971) showed that the failure could have been predicted with brittle fracture analysis.

The bridge was partly successful in the sense that the redundancy worked. The bridge remained in service for another year after the first girder failed. The bridge is one of the more dramatic cases illustrating the problems with termination of welded cover plates.

Another example of a bridge failure, but not collapse, from welded cover plates is the Yellow Mill Pond bridge on the Connecticut turnpike. The bridge is a simple span girder bridge with six to seven girders per span, and was opened in 1958. The girders are A242 W36 sections with two cover plates welded to the tension flange. In 1970, a major crack was noticed during the cleaning and painting of the bridge. The crack had started at the toe of the transverse weld of the primary cover plate, and extended through the tension flange and about half the web. The results of inspections over the next ten years are reported in Fisher et al. (1981).

By 1976, 22 out of 40 primary cover plate details that were inspected were cracked. In 1977, cracks started to appear at the end of the secondary (outer) cover plates. The study, and supporting laboratory testing, led to the E' category for fatigue. It also showed that fatigue crack growth can develop in welded connections when only a few stress cycles in the variable stress spectrum exceed the constant stress fatigue limit. The stress range of the Yellow Mill Pond bridge is similar to many cover plated girders. Thus, cracking can be expected when cumulative stress cycles are comparable to the Yellow Mill Pond Bridge. Regular inspection and repair has prevented this bridge from being a catastrophic failure.

A final example is the Dan Ryan Transit Bridge was built in 1968. A large crack was noticed on January 4, 1978, in a curved section of track where steel plate girders were supported by a steel box beam. The bottom flange of the steel girders penetrated the lower part of the web of the box beam. A slot had been cut in the web, the flange threaded through, and then the flange continuously welded to the box beam. A fatigue crack had initiated at the welded junctions of the edges of the steel beams which penetrated the box beam. At the time of con-

struction, the risk due to fatigue failure of this type of connection was not anticipated. Failure occurred because of the crack that was initiated by fatigue in the weld, the reduced fracture toughness of the steel due to low temperatures, and the high tensile stresses resulting from the weld restraint (Koncza, 1979).

One lesson to be learned from the Dan Ryan line is the value of having the bridge regularly inspected, even if just on a cursory basis, by competent people. In the case of the Dan Ryan line, the crack was noticed by Mr. Solarte, an civil engineer for the Rock Island line. He noticed the crack while he was looking out the window during his morning commute. The King's Bridge in Melbourne perhaps could have been saved if the initial girder failure had been identified during an inspection. The more people that are trained to at least give a cursory inspection of bridge, the better off we are.

A second general lesson relates to history, and is similar to the Tacoma Narrows failure. All the failures were quite similar to the Ashtabula bridge failure in that there was flaw, it grew from fatigue, and brittle fracture occured, aided by low temperatures. Bridge failures over 100 years ago are still teaching us lessons.

Tay Bridge, 1879

At 4:15 p.m., early in the evening Sunday, December 28, 1879, a North British Railway Company train left the station at Endinburgh. The engine, the luggage carriage and six passenger carriages traveled north through Burntisland, Fifeshire, and St. Forth taking on passengers along the way until the train carried approximately seventy-five passengers. Ahead lay the Tay bridge with 85 spans, the largest being 250 feet. The Tay was the first of two bridges that would cut the trip along the eastern coast of Scotland by 62 miles and two hours. It was an engineering marvel.

When proposed in 1866, many, including the railway companies, feared the scope of the project. Nothing like it had been attempted before. Nonetheless, in 1870 the design submitted by Sir Thomas Bouch had been approved by the British Government and work proceeded in 1872. The completed bridge was delivered in 1877, taking twice as long and costing twice as much as had been expected. Still, it had been completed and had stood for nearly two years, carrying passengers and goods safely between England and Scotland, but some still had their doubts. One engineer, John Fowler, had forbidden his family to travel across the bridge.

As the train left St. Forth, at around 7:30, five minutes behind schedule, the signal was sent to the signalman at the south end of the bridge, whom in turn telegraphed the train's progress to the north end of the bridge. As the signal was sent, the winds picked up. Less than two minutes later the bridge collapsed. The railway company staff prayed that the train had lost time between St. Forth and the bridge, but it was not so. At 11:00 p.m. a steamer was sent to survey the scene, but due to the bad weather, it arrived as the moon was setting behind the dense clouds. Despite the lack of visibility, the conclusion was inevitable. Thirteen spans were gone, a gap of 3,280 feet. Some aboard the steamer thought they could see survivors clinging to the piers, but they proved to be cables fixed to the abutments. Nothing remained of the train or that section of the bridge that had failed, save the stone foundations and portions of the brick abutments, from which thrust the fractured stumps of the iron uprights.

The failure of course came as a shock to a majority of the engineering community and immediately an investigation was begun. As is the case in many structural failures, many different factors contributed to the collapse. As one investigator put it, "the bridge was badly designed, badly constructed and badly maintained," a bad combination. Probably the most shocking of the facts revealed in the inquiry was that Thomas Bouch, the bridge's engineer, had not made any consideration in the design regarding wind pressure. He had based the omission on his correspondence with Astronomer Royal Sir George Airy in which Airy suggested that the average design wind pressure should be around ten pounds per square foot. This was an extremely low estimate considering that American engineers, as a result of previous failures, were designing for five times this pressure and that locals knew the winds in the area to be fierce.

The failure, though caused mainly by the low estimate of the wind loads, could at least be partially blamed on economics. In a previous project, the Belah Viaduct, Bouch had chosen a much more substantial system of piers and horizontal ties. When questioned about this fact during the inquiry into the Tay failure, Bouch stated that the weaker structure had been chosen for economic reasons. His original design for the piers had consisted of eight columns placed in four rows, but this proved too expensive, so the cheaper six column hexagonal pier design was adopted. Though economics can never be used as an excuse for bad design, it is an ever-present and powerful concern in every design.

Jones (1994) recently conducted an analysis on the Tay bridge failure using modern methods of engineering. The bridge failed when the towers supporting the high girders failed under the wind loading. The towers consisted of six cast-iron columns. The columns were built up of seven cast-iron flanged pipes. These were tied together by wrought iron bracing bars. The bracing bars were attached to the pipes through "snugs" which were integrally cast with the pipe flanges. There was poor workmanship in the castings; some snugs broke off the castings in the factory and were reattached by recasting the snugs insitu against the cold surface. Tests after the bridge failure showed the snugs to fail at approximately 24 tons, whereas in theory they should have failed around 200 tons. Problems with quality control and the use of castings was partly responsible for the failure of the Tay bridge, as with the Ashtabula bridge.

One of the more interesting aspects brought out by Jones (1994) was that if the wrought iron ties between the columns had been significantly weaker, the bridge may have survived. The ties were approximately 4 square inches in area. If they had only been 1.5 square inches in area, the ties would have yielded before the snugs broke off. The yielding would have allowed the tie to continue to carry load, and distribute excess load to other ties. A plastic mechanism would have had to have developed before collapse of the bridge. The horizontal load causing failure would have increased from approximately 50 tons to 70 tons, or a 40% increase. Although the bridge was underdesigned for wind, and may have eventually failed (a 40% increase in load would also have caused overturning stability problems), the capacity of the bridge could have been increased by decreasing the area of the ties, forcing a ductile instead of a brittle failure.

This analysis provides an important lesson with respect to bridge failures. Both the engineer and inspector need to be aware of the consequences of failure of a component. Particular care in design and inspection needs to be taken when examining members whose failure would lead to collapse of the bridge. Ideally, all failures would be ductile and a redundant load path would be provided for all members. This is not feasible, and specifications have recently addressed this through the identification of fracture critical members. For failures to continue to be componenets instead of collapses, and hence less catastrophic, bridges must be built such that component failures do not lead to a progressive collapse of the bridge.

Despite the failure of the Tay, the winds still blew across the Firths and the trip from England to Scotland was still far too long. The Tay was built for a reason, and that reason still existed. Bridges had to be built that could safely carry rail passengers across the Firth of Tay and the Firth of Forth. The original plan had been to construct a bridge, similar in design to that of the Tay, across the Forth, but with the failure of the Tay this was now out of the question. A new design was desperately needed. The challenge was taken up by Sir John Fowler, who had criticized the Tay Bridge from the beginning, and Benjamin Baker. With the benefit of Bouch's experience, Fowler and Baker proposed a much more stalwart design, which sported, as described by Fowler, the "straddle of Henry VIII" to withstand the gusts that had humbled Bouch's efforts. The bridge's design was to be based on a cantilever principle, massive arms of steel lattice balancing across the Forth in two giant spans of 1,710 feet. And strong it was, designed for 56 pounds per square foot of wind load, with stalwart columns consisting of cylinders more than twelve feet in diameter and 1-1/4" thick. This time cost was no concern. Though estimated to cost 1,500,000 pounds, the final cost was 3,500,000 pounds, and no one

seemed to be bothered by it. The Forth Bridge was not only to be the longest bridge in the world, but also the strongest and the stiffest. It had to be to regain the confidence of the British people.

The bridge, though an impressive engineering accomplishment, did have its detractors. Many saw the bridge as being unnecessarily ugly, and some considered it overbuilt, despite the recent fall of the Tay. Shortly after the Forth's completion, Theodore Cooper, a well-respected American engineer who had assisted in the construction of Ead's St. Louis Bridge, stated that the Forth Bridge was "the clumsiest structure ever designed by man, the most awkward piece of engineering in [his] opinion that was ever constructed". He went on to say that "an American would have taken that bridge with the amount of money that was appropriated and would have turned back 50 [percent] to the owners, instead of collecting when the bridge was done, nearly 40 [percent] in excess of the estimate." Cooper would later get the opportunity to try to prove his point.

The Quebec Bridge, 1907, 1916

The Quebec bridge is quite unique in that it failed twice, both times during construction. A description of the first failure is given by Tarkov (1986).

Cooper's chance to prove his statements concerning the Forth Bridge would come with the need for a bridge to cross the St. Lawrence River near Quebec. Cooper had attended the annual convention of the American Society of Civil Engineers in the summer of 1897 in Quebec City. Among the topics discussed was the proposed bridge to cross the St. Lawrence River. The company in charge of the endeavor was the Quebec Bridge Company, which since it inception in 1887 had been plagued by financial troubles and therefore had accomplished virtually nothing to that point. Cooper was a well-respected consulting engineer. He had graduated from Rensselaer Institute, served in the Navy during the Civil War, worked under Eads during the construction of the St. Louis Bridge, and had been superintendent of Andrew Carnegie's Keystone Bridge Company before going into consulting. During that time he had been an outspoken critic of many practices of the engineering community, including the use of arbitrary factors of safety and codes of practice. He believed instead the engineer should rely solely on his own abilities and knowledge in designing suitable structures. He had also done something that many of his contemporaries had failed to do; he had published his thoughts and theories. His written works included books on bridge design and the now commonplace locomotive wheel loadings. The one thing he had not yet accomplished in his 58 years was to oversee a truly monumental engineering project. He saw the Quebec Bridge as that monumental work, stating openly that it would be his final project and his crowning achievement. So, despite the knowledge that the Quebec Bridge Company was in dire financial straits and would have difficulty providing him proper remuneration for his work, Cooper signed onto the project.

His first duty was to review the bids from the prospective contractors with directions to keep in mind the weak financial condition of the organization. The Quebec Bridge Company also made it clear that they desired to award the contract to the Phoenix Bridge Company of Phoenixville, Pennsylvania. Whether or not this had any effect on Cooper's final report is not clear, but he did endorse Phoenix's proposal. Cooper then called for a more extensive study of the riverbed. In 1900, after examining the results of the study, Cooper proposed increasing the span of the bridge from 1,600 feet to 1,800, making it the longest span in the world. The reasons he gave were that piers constructed further out in the channel would be more vulnerable to ice flows and would take a year longer to complete. Ever aware of the cost constraints of the project, Cooper proposed to deal with the increased loads due to the increased span by simply increasing the unit stresses allowed in the specifications.

Despite the fact that the bridge appeared to be on budget, at least on paper, the Quebec Bridge Company was still unable to guarantee its ability to pay any of the parties involved for the work they were doing. For this reason, work had virtually stopped at Phoenix between the years of 1900 and 1903, when the Canadian government guaranteed a bond issue of $6.7 mil-

lion. The Quebec government, for so long apathetic about the bridge, now was determined that the bridge open in time for Quebec's Tercentenary celebration in 1908.

Suddenly the project was pushed into high gear. Suddenly the changes proposed by Cooper found relevance with the people at Phoenix and the Department of Railways and Canals. When the revised specifications crossed the desk of Peter L. Szlapka, Phoenix's design engineer, some concerns were raised about the higher stresses, but these were soon set aside, as being justifiable considering the magnitude of the project. Things did not go so smoothly at the Department of Railways and Canals. An engineer by the name of Robert Douglas criticized the high stresses allowed in the new specifications and reported his concerns to his supervisor, Collingwood Schreiber. Schreiber concurred with Douglas' opinion that the determination of unit stresses should not be left to the judgment of one individual, namely Mr. Cooper.

To Cooper, this was simply unacceptable. He immediately went to Ottawa to have the matter settled. It soon was. Though the plans would continue to pass through Schreiber's office for routine initialing, Cooper in practice had the final say concerning the project. The trip to Ottawa was remarkable in that Cooper had visited the site only three times, the last visit in May 1903. After that final visit Cooper would refuse all requests that he examine the site, stating that his physician had advised him not to travel. Cooper had never been fond of site visits and had in fact required a clause in his contract which limited his site visits to a maximum of five days a month.

As Coopers health continued to deteriorate, he actually made several attempts to sever his association with the project. Twice in 1904 he had asked to be relieved of his duties, once of S.N. Parent, president of the Quebec Bridge Company, and once of John Dean of the Phoenix Bridge Company. Both men quickly dismissed his requests. Cooper would later state that "a pride and a desire to see this great work carried through successfully" kept him from pressing the matter further. By this time erection had begun, though no one involved in the project, save Cooper himself, was sufficiently qualified to act with authority. Cooper had placed his confidence in Szlapka, who, though a seasoned engineer with over twenty years of experience, was essentially a desk engineer without the required field experience necessary to oversee the progress of so monumental a work.

In 1905, Cooper had a recently graduated engineer, Norman McClure, situated in Quebec to report on the progress of the bridge. McClure was the perfect man for the job in Cooper's eyes. He had enough technical knowledge to accurately report on the erection, but had not the experience to act independent of Cooper.

For another year the erection progressed without incident. That is until on February 1, 1906, a report from E.L. Edwards, inspector of materials at Phoenix, stated that the weight of the steel provided for the bridge had far exceeded the original estimates. Due to lack of confidence in the financial position of the Quebec Bridge Company, no one at Phoenix had recalculated the weight of the bridge after the span had been increased. Even after the design process had begun in earnest, after the moneys were secured, the original weights remained unchecked. A crucial step in the iterative design process had been neglected by both Szlapka and Cooper, and now a critical decision had to be made. The six panels of the south anchor arm were in place, and the tower and two panels of the south cantilever had already been fabricated. Cooper calculated that the stresses, which he had already allowed to be increased once to allow for the longer span, would now be increased another 7 to 10 percent to allow for the underestimated weight. Cooper decided that the stresses were still safe and permitted work to continue. The only other option he had was to order that the project be halted and begun again from the start, an expensive and embarrassing alternative. By June the weight of the final structure rose from 62 million pounds to 73 million pounds.

In the summer of 1907, McClure reported to Cooper that they were having problems fitting some of the lower chord compression members. Cooper showed no concern recommending only that the pieces be fitted before the full loads were applied to them. But the problems continued to worsen. On August 6, McClure reported that two of the lower chords in the south

cantilever arm were bent. Cooper now showed some concern asking McClure to uncover how the chords had become bent. On August 12, McClure discovered another bend in a splice between two chord members. Deans, the Chief Engineer at Phoenix stated that the members had left the shop bent and that there was no need for concern, but McClure continued to insist that the members had shown deflection only after being installed.

The work continued, as did the discussions about the bent members. McClure had the deflections measured. A chord that had been three-quarters of an inch out of line a week before was on August 27 two and one-quarter inches out of line. He wrote Cooper immediately about his findings and his concerns. His concerns were somewhat eased by the fact that Phoenix's general foreman had halted the erection, fearing for the safety of himself and his men. He soon changed his mind and the very next day work had resumed. The decision was supported by Chief Engineer Hoare of the Quebec Bridge Company, who feared that halting the work at that time might mean waiting until the spring to continue the work.

As the work proceeded, under the burden of fear, Phoenix continued to insist that the bends in the members had occurred in their shops. Hoare, unqualified to make a decision on the matter, sent McClure to New York to discuss the matter with Cooper, in his Manhattan office. When McClure arrived, Cooper had not yet had the opportunity to read his letter. After doing so, he spoke briefly with McClure. Cooper then sent a telegram to Phoenixville that read, "Add no more load to bridge till after due consideration of the facts. McClure will be over at 5:00 o'clock."

Based on McClure's letter, Cooper had assumed, incorrectly, that the work had stopped. Nonetheless he asked McClure to wire his decision to Quebec. McClure neglected to do so. Cooper's telegraph to Phoenix, which had arrived before McClure, was also disregarded by John Deans, so the work continued.

Two days later, just before the whistle would blow for quitting time, the bridge failed, taking seventy-four workers to their death. The bottom chord had buckled, and witnesses describe the failure as the bridge melted like "ice pillars."

Several lessons were certainly learned from the Quebec bridge failure. Proper heed needs to be taken of warning signs. There was sufficient evidence of problems with the lower chord to warrant more action than was taken. Components that show distress need to be investigated and examined before they lead to collapse.

The failure of the Quebec bridge was basically a stability failure. Stability needs to be carefully maintained during all phases of a bridges life, from construction to demolition. Insuring stability is particularly critical when erecting or working on a bridge. Several recent failures, including a plate girder bridge under construction in Tennessee, show that stability still can be a problem.

The story of the Quebec bridge was not over. A new bridge was designed, and the erection of the superstructure commenced in the summer of 1913. Again, a cantilever bridge was to be built, but the center span was to be hoisted into place, rather than constructed in place as was the case with the original bridge. The cantilever trusses were completed by the summer of 1916. The center span, which had been constructed three miles down the river, was ready to hoisted into place. The lifting of the center span commenced on September 11, 1916. At 6:35 a.m. the span reached the bridge site and at 7:40 a.m. all four corners had been attached to the lifting hangers. The jacking operation was done in stages of two feet. After four lifts, work was suspended for breakfast. Everything was going as planned, and the work remaining to be done was merely a repetition of operations already successfully completed. It was felt that the most difficult part of the work was accomplished.

At 10:30 a.m. jacking operations resumed and one more lift was made. The pins connecting the lifting jacks to the fixed jacking girders were installed. This transferred the load directly to the cantilever trusses. The load on the jacks was released and they were being lowered for another lift when at 10:50 a.m. a sharp report was heard and the span slid off its end

supports and fell into the river. The loss of the span was attributed to the failure of a temporary cruciform bearing casting.

A year later, a new center span was successfully lifted into place, and in September of 1917, wind struts and bracing were installed between the cantilever arm and suspended span to finally finish the bridge. A train finally crossed the bridge on October 17, and the bridge was handed over to the operating department for regular service on December 3, 1917. Thus, the 3239 ft cantilever bridge (1800 ft clear span) was finally completed.

Point Pleasant Bridge, 1967

The Point Pleasant bridge linking Point Pleasant, West Virginia and Ohio failed on December 15, 1967. Forty-six people were killed in the collapse of this forty year old bridge. The bridge was a rather unique eyebar suspension bridge, with the only similar bridge at the time in North America being the twin of the Point Pleasant bridge in St. Mary's, Ohio. A similar bridge was known to exist in Florianopolis, Brazil.

The bridge had a main span of 700 feet, with side spans of 380 feet. The panels were 25 feet long. The suspension "cable" was formed with a series of eyebars; the eyebars also forming the top chord of the stiffening trusses in the center portion of the center span and at the ends of the bridge.

The failure initiated in an eyebar on the west side of the Ohio tower. One of the two eyebars fractured, causing the entire bridge to collapse. The eyebars were made of heat-treated 1060 carbon steel with a yield strength of 75 ksi. Various failure theories have been put forth.

Dicker (1971) concluded that the primary failure was due to fatigue movement between the pin and the eyebar. The movement occurred because a suspension bridge carries load more by changing geometry than changes in the stress in the members. The rotation at the joint where failure initiated was on the order of 10. Dicker estimated that there were between 106 and 107 fatigue cycles at the time of failure. The friction between the pin and the eyebar caused shear stresses between the two, which would theoretically cause an infinite stress concentration at the end of bearing. This is also the location of the largest tensile stress due to the applied load. Dicker develops a failure theory that after the one eyebar failed from fatigue the structure did not collapse. Instead, the load was transferred to the other eyebar, which due to the eccentricity, forced the pin cap off. This is consistent with eyewitness accounts of a loud "clanging" 30 minutes before the collapse, and observation of a large nut with a shank of a bolt, and another observation of an object resembling a hubcap (which was apparently the pin cap). If this reconstruction is true, there was about a half-hour warning before the collapse.

Scheffey (1971) postulated that the failure was due to either stress corrosion cracking or corrosion-fatigue cracking. Stress corrosion cracking occurs in high strength steels when certain environmental conditions are right. For example, sulfur can cause the absorption of hydrogen, resulting in embrittlement of the steel. In corrosion-fatigue, the crack propagation from fatigue is aided by the corrosion. Scheffey (1971) concluded that it did not matter what the actual mechanism was, but that either stress corrosion or corrosion-fatigue cracking led to the fracture of the eyebar. Perhaps this complements Dicker's theory in that corrosion exacerbated the fatigue, or that possible the stress corrosion caused the final fracture.

There are several implications of this failure for railroad bridges. Eyebars in truss bridges would typically have less rotation than in a suspension cable, perhaps an order of magnitude less. Some members of a truss, such as the lower chord, would experience fewer cycles of loading (essentially one per train). The Point Pleasant bridge had only two eyebars in each chain; many members will have more than two eyebars giving greater load carrying capacity should one eyebar fail. Steels used in railroad bridge construction are typically lower strength than the steel in the Point Pleasant bridge, making members less susceptible to stress corrosion cracking. Thus, many of the problems associated with the Point Pleasant bridge will not be present on the typical railroad bridge. However, the Point Pleasant bridge does point out the problems that can occur in eyebars and reinforces the need to keep the entire life cycle of a bridge in mind when designing and inspecting.

One of the major flaws in the eyebar design of the suspension cable was that the eye of the eyebar was virtually impossible to inspect and maintain. Since the components in the suspension "cable" were so closely spaced, paint could not be applied to the area of highest stress. Additionally, the close spacing provided an area where water could collect and cause the corrosion which aided in the eventual failure.

The failure of the Pt. Pleasant bridge was essentially a failure due to distortion induced fatigue. A bridge has to deflect to carry the load. If the bridge is restrained from deflecting, secondary stresses will be built up. One relatively common example of distortion induced fatigue is welded plate girders. Cracks occur at the stiffener or diaphragm connections due to restrained out-of-plane distortion (Sweeney, 1978; Fisher and Mertz, 1985). The Pt. Pleasant bridge was an extreme example of distortion induced fatigue.

Eads Bridge, The Failure that was Prevented

The Eads Bridge in St. Louis, completed in 1874, continues to provide a vital link across the Mississippi. However, the Eads bridge was not the first bridge to be proposed across the Mississippi at St. Louis. Thirty-five years before the completion of the Eads bridge, Charles Ellet had proposed a suspension bridge across the Mississippi at St. Louis. During the subsurface investigation for the piers, the auger could not be driven more than 20 ft. below the water in mid-stream and on the Illinois side. Ellet concluded that foundations in mid-stream could be founded on this soil, stating that the riverbed was "superior to the soil which sustains some of the most celebrated stone bridges in Europe," and firm enough to drive piles into (Petroski, 1995). Ellet never got the backing needed to construct the bridge, which is probably fortunate. The foundations for his bridge would have most certainly scoured away, perhaps even before the suspension cables were in place.

Eads understood the river bottom, and the problem with scour. Eads had gained his fame and fortune in the salvage business, and probably knew the bottom of the Mississippi river better than anyone else. He took his caissons to rock, and the Eads bridge today stands because of Eads' understanding of the potential and problems with scour.

Scour is one the worst problems facing bridges at present, being far more responsible for bridge failures than any other cause. There have been several quite well publicized failures from scour. One is the Scoharie Creek bridge. There had been concern during the design that the bridge constricted the river too much, which proved to be true.

Railroad bridge failures from scour and washouts have been well documented. A washout in 1923 killed 31 people. Ironically, the bridge had been inspected an hour before the washout, and reported to be safe. It appears a sandbar holding back a large basin of water had failed, giving rise to a sudden flood (Reed, 1968). Inspectors need to be aware of external factors, some beyond the railroads control, that can affect the performance of a bridge.

A recent washout of a Burlington Northern Sante Fe bridge over the Wenatchee River was partially due to restricted flow. An embankment had been armored with rip-rap several years earlier when high water threatened to take out an abutment. The "hard surface" created by the rip-rap directed flow at the foundation of a pier. Placing the rip-rap saved the abutment, but perhaps at the expense of the pier. The pier was thought not to be vulnerable, since according to plans the pier was founded on "rock." Geotechnical information, particularly from old plans, needs to be carefully examined and verified.

SOURCES OF BRIDGE FAILURES

With the first part of this report dealing with case histories of some of the more memorable bridge failures, it is important to note that our past and more recent bridge history has taught us three important facts. First, you cannot protect yourself against every conceivable design and loading condition. Another important lesson learned is that whenever there is a bridge problem it is essential that the root cause of the problem be identified because many times the problem is not immediately obvious. Finally, the cause of a bridge failure should be discussed within the profession in order to prevent repeat occurrences of the same failure.

Continuing with the theme of bridge failures, an attempt has been made to categorize the "Sources of Bridge Failure" with regard to railroad structures. Four sources are: Bridge failures due to design errors, failures during construction, failures due to use and failures due to natural phenomena. A brief discussion of each of these potential sources of failure follows.

DESIGN FAILURES: As previously mentioned, early in the history of railroad bridge design a bridge failure or collapse was considered as part of the risk of doing business. It took a significant watershed event to change the prevailing management attitude and to alert bridge engineers and bridge designers that a bridge failure due to design error was an entirely unacceptable practice. Even with accelerating industry growth and the availability of new materials for longer and longer spans, the designer must take the appropriate time to carefully consider and thoughtfully prepare a bridge design. Because of this change in attitude, more recently, there have not been any railroad bridge collapses due to design errors.

CONSTRUCTION FAILURES: In most cases, when a bridge fails during construction a train is not on the track, consequently the likelihood for a catastrophic failure where many lives are lost is somewhat remote. It is important to reiterate that most bridge failures during construction involve concrete structures and the typical failure mode is falsework failure where the temporary shoring fails to support the concrete during the curing process. Generally, bridge failures during construction can be classified into three categories as follows: Failure due to poor fabrication practices, failure due to poor workmanship in the constructed product and use of improper materials that do not meet the specifications.

SERVICE FAILURES: Principal sources of bridge failures while a structure is in service are as follows: Problems associated with overloads, problems associated with shifting loads, and problems associated with impact from either ships, barges, cars, trucks, and derailments. Two other sources of service failures are fatigue of older bridges and of course just the age of the structure which at times limits the carrying capacity of a line.

NATURAL PHENOMENA AND OTHERWISE: This category of bridge failure can also be identified as "Acts of God". Nearly every railroad has experienced some unfortunate experience such as an earthquake, hurricane, high wind, fire, flood, erosion, or slide which can be composed of either mud, snow or earth. In the category of "Otherwise" two sources of bridge failure can be identified and they are vandalism and terrorism. Both of these hostile acts are nearly impossible to design for and consequently they are not discussed any further.

As previously indicated, in today's engineering environment, catastrophic bridge collapses are a rare occurrence and are usually the result of a natural phenomena which is difficult to design for. This rarity of bridge collapse is due to the care taken in the design and construction of the structure and the follow up regular inspection and maintenance of each structure that is typically provided by the railroad. In addition, railroads provide warning signs, lights and other devices to individuals operating other forms of transportation to alert them of the presence of the bridge.

Because the frequency of a major collapse is remote, it becomes important to focus on bridge component failure and the sources of the failure. In the time frame allotted it is impossible to address all the bridge component service and maintenance related issues that have been experienced by the numerous bridge types. Consequently, only the more common problems or issues that are associated with component failure are presented.

Generally, nearly every railroad has a population of older structures that were assembled with riveted joints and possibly pins at the connections. This is especially true for older trusses. These older trusses which are composed of built-up members, experience some unique problems. For example, corrosion of the older members is more prominent due to the age of the structure. Significant corrosion problems can generally be found in the following locations:

1. Pack rust between the faying surfaces of built-up members especially the lateral bracing, the cover plates of floorbeams and stringers and the web plates of built-up chord members.

2. Rust and corrosion can also be found in the steel rocker bearings. Sometime the rust can be severe enough to seize the bearings and transmit undesirable lateral forces to the substructure units.
3. On eyebar connected trusses, pack rust can also develop between the eyebars at the eyebar nest around the pins and freeze the adjacent eyebars to each other. This corroded situation can introduce undesirable bending forces into the eyebars.

Some other issues regarding older trusses are as follows:

4. On older pin connected trusses that are 100 to 150 feet long, and have an even number of panels there is the problem of lower chord gusset plate wear at the midpoint panel around the connecting truss pin. Due to the stress reversal created by the passing train, the center pin experiences a cyclic loading condition every time a car passes. This causes the pin to rock in the hole of the gusset plate and tends to elongate the gusset plate pin hole over a period of time.
5. Another bridge issue is the failure of the first interior hanger on not only old trusses but also newer trusses. It has been known for many years that the first interior hanger of a truss has been vulnerable to fatigue cracking and at times even failure. The hanger cracks just above the lower chord gusset plate and many times the crack will initiate in the top row of bolts or rivets.
6. Still another issue of the older pin connected trusses is the rotation of the pins in the truss joints. At times the pin rotation can be severe enough to move the pin laterally and threaten the structural integrity of the joint and the stability of the structure. The lateral forces created by pin rotation can be of sufficient magnitude to even fracture the restraining devices that are designed to retain the pins in their proper position.
7. Older pin connected trusses also have a unique wearing phenomena where eyebar diagonals are used as "X" bracing in a truss panel near mid-span of the truss. At times the eyebars rub against each other due to the cyclic loading and this abrasive rubbing action causes premature section loss in the eyebar members and creates stress risers in the members.
8. Another issue is that the bearings were typically designed for much lighter loads than they experience today and consequently the bearings have a tendency to "pump" on the concrete pier caps and grind into the top of the pier. If not corrected, this can create an undesirable or even hazardous track profile.
9. Many older structures have substructure units that are typically composed of masonry and/or unreinforced concrete. As time and the natural weathering deteriorates the joint mortar, the structural integrity of the bridge pier or abutment can be compromised.
10. One of the more prominent natural phenomena that can lead to a bridge failure is a flood or tidal surge. Most bridges on America's rail system were analyzed for river scour during flood conditions. Consequently, when the 100 year flood event occurs, many bridges are vulnerable to scour around the piers and abutments and possible collapse.
11. Timber structures are naturally vulnerable to fire. Many times this event is a man made event rather than a natural phenomena. The fire could be started by such routine maintenance items as track grinding, careless welding of misuse of a torch. Another threat of fire is the rare event when someone deliberately sets a fire.

Some of the more frequent bridge failures are due to clearance problems, not only horizontal and vertical clearance above the top of rail, but also horizontal clearance between the piers and vertical clearance below the bridge. Shifting loads, oversize loads, and derailments can create havoc on an old narrow truss or thru plate girder. Oversize trucks have been known to impact the underside of a bridge and cause the structure to be closed to rail traffic to make repairs. Some of the more memorable bridge damages are due to ship and barge impacts. Nearly every railroad in the country has had at one time or another actually witnessed a barge

using the shear fence on one of their structures as a "deflector" to navigate the channel. In some instances this occurs on a daily basis.

As one can see, railroad bridges are vulnerable to collapse and component failure from many sources. Errors in design, poor fabrication and construction practices, service related incidents and natural phenomena can create vulnerable situations and conditions for bridges. Fortunately most bridges failures begin with a bridge element or component failure which can be identified and corrected through regular inspection and maintenance. Also, most catastrophic bridge collapses that do occur are not due to service loads but rather to rare acts of God such as flood, fire, slides and earthquakes. On these rare occasions some advance warning is usually evident and traffic can be terminated until the threat is passed.

In summary, the catastrophic railroad bridge collapse is a rare occurrence due to the care and precaution taken during design, fabrication, construction, and regular inspection and maintenance of a bridge. It is clear that all of these bridge life cycle components play an important role in determining the service life of a bridge. Each of us play a part in determining how effective a bridge will be and the costs associated to keep it in service.

What follows is a listing of the more common bridge types found on a rail system and a summary of the bridge issues that could make the bridge vulnerable to component failure and ultimately bridge failure.

TIMBER BRIDGES AND TIMBER TRESTLES (OPEN DECK AND BALLAST DECK)

Typical bridge issues and problems for timber bridges are:

1. Deterioration or decay of the timber piles
2. Crushing of the timber pile caps under load
3. Rotting of the timber around the connections
4. Insects and marine borers
5. The ban of the use of creosote which offers timber structures some protection
6. Flexible pile caps which allow unequal load distribution to the piles
7. Failure of the timber stringers in horizontal shear and bearing
8. Connections that work loose due to crushing of the wood around the steel fasteners
9. Fire

WELDED DECK PLATE GIRDER BRIDGES (OPEN DECK)

Typical bridge issues and problems for Welded Deck Plate Girder (DPG) bridges are:

1. Corrosion of the top and bottom flanges
2. Corrosion of the bearing stiffeners at the bottom flange
3. Corrosion of the lateral bracing and the lateral gusset plates
4. Out of plane bending in the web at the vertical stiffeners and lateral gussets
5. Rocking of the top flange at the flange to web weld due to uneven loads from the ties

WELDED DECK PLATE GIRDER BRIDGES (BALLASTED DECK)

Typical bridge issues and problems for Welded Deck Plate Girder (DPG) Bridges with ballast decks are:

1. Corrosion of the top and bottom flanges
2. Corrosion of the bearing stiffeners at the bottom flange

THRU PLATE GIRDER BRIDGES (TPG)

Typical bridge issues and problems for Thru Plate Girder (TPG) Bridges are:

1. Horizontal clearance between girders
2. Insufficient bracing with full depth kneebraces
3. Corrosion of lateral bracing and the gusset plates
4. Corrosion of the bottom flange plate

DECK TRUSSES (OPEN DECK)

Typical bridge issues and problems for open deck Deck Truss Bridges are:

1. Corrosion of the stringer top flange
2. Corrosion of the top chords
3. Corrosion of the lateral connections
4. Corrosion of the floorbeam top flange

THRU TRUSSES (OPEN DECK)

Typical bridge issues and problems for open deck Thru Truss Bridges are:

1. Corrosion of the stringer top flange
2. Corrosion of the bottom chord lateral gussets
3. Corrosion of the lateral bracing
4. Corrosion of the floorbeam top flange

CONCLUSIONS

Many lessons can be learned from bridge failures. Some of the lessons will be very specific, and relate to a particular type of bridge. Other lessons will be more general, and relate to the practice of bridge engineering and inspection. A summary of the some of the general lessons is as follows:

- A careful examination is needed after each bridge failure. What may appear initially to be the cause of failure may not be the true cause. The profession only benefits when there is a thorough public report issued on the failure.
- There appears to be a historical pattern to bridge failures in terms of frequency. Engineers from one generation need to pass on their knowledge to the next. Some types of failures have repeated themselves, as much as 100 years later. A study of historical bridges can be very enlightening; every engineer should spend a few days in the library.
- Thought needs to be given to the result of failure of a member. Redundancy and ductility are necessary for a bridge to survive after a component failure. Warning signs need to be taken seriously.
- Old-fashioned common sense is needed now more than ever.

An examination of bridge failures indicates the move from collapses to component failures. This speaks well for both the design and inspection of bridges. Component failures are detected and repaired before they cause bridge collapses.

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Thank you. I'll close with that and Dick can answer all your questions. (Laughter) (Applause)

President Bradley: Thank you, I appreciate it. That was a great presentation. I know it was a touchy topic to start out with but you guys handled it very well.

Our next feature is a presentation on the Illinois Central's concrete trestles. It's going to be presented by Allen Dunn, bridge and building supervisor with the Illinois Central.

Allen graduated from Mississippi Delta College in 1969 and began his railroad career with the Columbus and Greenville Railroad. In 1973, he joined the IC and since then he has been with the IC. Please welcome Allen Dunn. (Applause)

ILLINOIS CENTRAL'S CONCRETE TRESTLES

Allen Dunn

B&B Supervisor
Illinois Central

First of all, I am giving you a chance if you don't want to go to sleep, get up and leave now. I am just like a sleeping pill. Every time I do a job, I always have an A plan and a B plan. Well, I am a going to trash my A plan. My wife and I left home Saturday afternoon and we got about 15 miles from the house when I looked over and said, "Did you get the tickets?" She said, "No, I thought you had the tickets." So we went back and got the tickets and got back on the highway. I looked at her and said, "Did you get my tape?" She replied, "No, I thought you got the tape." So we went back and got the tape. Then we got on train and came on up. Of course, I hadn't slept any since I have been up here. I was worried about this as I am no speaker. Anyhow, last night at about 11:00 o'clock, I looked over to her and I said, "Where is my speech? You didn't get it?" (Laughter) She said, "No, I didn't get it." So then I wrote my speech on my hand during lunch. I then went to the restroom and washed my hands. (Laughter) Well, there goes my speech. So it looks like we are going to plan B which is on the tape. I just hope I brought the right tape. (Laughter)

Safety and the prevention of injuries is the first importance in the discharge of duty at all time on the Illinois Central Railroad.

I will be discussing with you step by step how the IC Railroad builds concrete bridges. The first thing we do is open the ballast deck trestle to an open deck trestle and then we build templates to drive the piling. You will see how important it is for you to build templates.

Here we are driving a 65-foot concrete piling. After we get the piling to the correct depth and pile bearing, we make our first cut with a concrete breaker. The breaker is a hydraulic concrete breaker.

As you will notice, the employees working here have the proper safety equipment on. Here the two men are cutting the 65-foot concrete piling off with a concrete breaker. This is a quick method of getting it cut the first time so trains can run as soon as possible after the piling are driven.

Here we are putting the saw guide clamps to a quarter piling. After the saw guide clamps are put to the quarter piling and adjusted to the correct height, we can connect the saw guide to the clamps.

After getting the saw guide to the proper elevation, we then put on the saw carriage. This is a saw carriage with the saw mounted to the top. They are adjusting the saw clamps and the carriage to the proper elevation for the pilings to be cut. They have to shim it up to get it to the right elevation. They are still doing some final adjusting. It takes two people to put this together.

The saw is a concrete saw and it runs on hydraulic. It also takes water to keep the bar cooled down. The chain is a diamond cut chain. The company that produced the saw is RGC. They worked with us to get us the proper chain to cut the concrete pilings and the rebars into the piling. It takes about 45 minutes to cut one piling off.

Here you see the clamps. They are wrapped around the piling and then tightened with a screw to tighten it up snug against the piling.

Here the men are adjusting the saw guide to the proper elevation and making sure it's level.

This is the water pump. We put 80 pounds of water pressure on the chain saw for lubrication. It helps take the grind out of the chain and the piling to keep it off the saw. We use about 500 gallons of water per bent to cut the bents off.

This is a hydraulic pump. It runs two 5-gallon per minute tubes, 8-gallon per minute tubes, and 10 gallons. This is also made by RGC.

With the saw in operation, you see a fine mist of water coming out. Like I said, it has 80 pounds of pressure of water coming into this saw. It comes into the backside and it has veins down the middle of the bar which come out by the chains. It keeps a good lubrication on it. The more water you put on the chain and the bar, the longer it will last. The bar and the chain will last a lot longer the more water pressure you put to it. We found out about 80 pounds of pressure is about the right pressure to put on it. After you get this set up, one man can sit there and cut the piling off by himself while the other people are doing something else on the job.

Here the piling has been cut off level to the right elevation. The man now is installing the neoprene pads. We put them on and it takes the fluctuation after the pilings have been cut. They are half an inch thick, 14 by 14. After installing and lining them up, then it's time to set your precast bent cap. The machine now brings the bent cap out lowered to be put in place.

Looking under the bottom of the bent cap you can see the indenters where the pile goes up and you have one inch tolerance on each side of the piling. That's why I say when you build you have to have templates to drive your piling to keep them in the right position because when you get ready to set this bent cap if your pile is off, it just will not go. Then you have to do a little trim work. So if you will take time when you build your templates and put it to specifications then you will not have any trouble installing your bent caps. The bent caps are three feet wide, three feet tall and 14 feet long.

In this picture, about half way up on the side you will see some little holes. Those little holes go into the indenter. After you get the caps set on the piling, we have some forms we put on the bottom and close up the bottom of the pile. Then we pump master flow grout into the holes until it overflows the hoses on both sides of the gaps.

Now he is readjusting the neoprene pads. He is looking to see if everything is going to fit in place. We then are going to lower the cap down onto the piling. You have to be very careful so the cap will not catch the neoprene pads. If it does, it will mess them up a little bit and you have to start all over again.

This shows the little holes I was telling you about. We pump the master flow through these holes. There is one on each sides of the pier cap or bent cap directly over the piling. After we close the bottom up, we pump it in and that's what seals it. That is the indenter under the bottom of the piling. You can see it's about an inch or maybe an inch and a half. You have about an inch or inch and a half clearance all the way around.

Here we are checking the correct length to see if the bent is in the correct position. The bridge is taking 26-foot T girders. He decided he had to move it back a little bit so he is making his final adjustment on aligning this bent cap up with the piling.

We were sitting the bent cap with three men and then just one person stays up there cutting on the concrete piling. It took us about 45 minutes to an hour to set the bent cap in the same time it takes to finish cutting off one concrete piling. As you cut the concrete piling and you get over about three quarters of the way, you have to put wood wedges in. You need to hammer them in. You would put one on the opposite side and one on the starting side where you start to saw. What it does is hold the piling up off the saw and will not bind it until you get through. We have had pilings sticking above about four feet and still use the wedges and everything goes fine.

Here we are adjusting the saw to the next piling. This picture shows the top of the piling he just cut off. It cuts real slick. The reinforcing steel is visible as well. Here we've disassembled an old timber bridge taking the timber out so we can set the new 26-foot T girders. While doing this operation we were running partly on the new bridge, concrete trestle bridge, and an old timber bridge.

One man gives signals to an operator on the pile driver. We only have one person who can give signals. The pile driver engineer does not move unless that one person designates to give

the signal. He will not move until he has been told by that certain person unless the pile driver sees something that might injure someone. Then he makes a move on his own if he thinks it is absolutely necessary.

Remainder of Text Unavailable.

Mr. Lileikis: Thank you, Allen. At this time, I'll turn the podium back to Mike Bradley for the Business Session

Mr. Bradley: Thank you, Joe.

At this time, I would like to introduce the past presidents who are in the audience today. Would you please rise as I call your name and remain standing until all have been introduced.

Paul Saletnik, Meridian Engineering, president 1992-1993; Mark Walbrun, TransSystems, president 1991-1992; John Horney, Carter Burgess, president 1990-1991; Ray Tallent, Norfolk Southern, president 1988-1989; Don Lewis, Illinois Central, president 1987-1988; John Kapp, Conrail, president 1986-1987; Jim Williams, EJ&E (retired), president 1984-1985; Jim Budzileni, Illinois Central (retired), president 1983-1984; Wally Sturm, EJ&E (retired), president 1978-1979; and R.D. Hellweg, Amtrak (retired), president 1966-1967. Have I missed anyone? Let's give these gentlemen a hand for all the work they've done for the Association.

The Nominating Committee recommends the following: Directors, with terms expiring in 1999: Steve Ross, senior structures inspector, Conrail; Gordon Davids, bridge engineer, FRA; Preston Sargent, manager mechanical systems designer, Union Pacific.

For senior vice president, Bob Carter, manager public programs, BNSF. For junior vice presidents, Dave Franz, bridge engineer, KCS; and Jimmy Neece, superintendent facilities and maintenance, CSX.

For treasurer, Don Lewis, assistant engineeer structures, IC.

According to the Constitution, senior vice president, Joe Lileikis, automatically assumes the position of President.

Since no other nominations have been received from the membership, I suggest we approve the election of the slate recommended. May I have a motion? Any opposed? All in favor?

We'll go on to the following reports. If you have any questions, please hold them until all the reports have been given.

MEMBERSHIP REPORT

September 1, 1995, through August 31, 1996

Total members, September 1, 1995			830
New members since September 1			93
Reinstated members			2
			925
Less: Deceased – Honorary		1	
Associate		1	
Life		1	
Dropped – Active		36	
Associate		15	
Life		116	170
Total members, August 31, 1996			755

TREASURER'S REPORT

September 1, 1995, through August 31, 1996

Checking account balance, September 1		$12,384
Receipts		
Dues	$16,695	
Advertising	9,825	
RR Contract Seminar	1,975	
Bridge Inspection Seminar	22,775	
Bridge Repair Seminar	8,100	
Profit from 1995 conference	3,573	
Interest on checking account	310	
Miscellaneous	335	63,588
Transfer funds from money market		10,000
		$85,972
Disbursements		
Salaries	$16,097	
Payroll taxes	1,342	
Employee savings	481	
Office rent, util., insr. & taxes	2,946	
Office supplies	928	
Equipment purchase, rent & repair	549	
Stationary & printing	4,106	
Postage	2,487	
Conference	972	
RR Contract seminar	1,349	
Proceedings	16,129	
RT&S subscription	583	
Bridge inspection seminar	10,647	
Bridge repair seminar	7,603	
Scholarship awards	3,000	
Executive committee meetings	2,232	
Temp. office help & comp. cnstlnt.	1,412	
Adjustment to Supts. from July 1985	1,008	
Miscellaneous	768	74,639
Checking account balance, August 31		11,333
Funds on Deposit - Advance Bank, Homewood, IL		41,721
Total Funds, August 31, 1996		$53,054

AUDIT COMMITTEE REPORT

To: Members of the American Railway Bridge and Building Association

We, the undersigned members of the Audit Committee, have examined the financial records of the American Railway Bridge and Building Association for the period September 1, 1995, through August 31, 1996, inclusive and have found them to be correct as of August 31, 1996.

Respectfully submitted,

J.R. Williams
W.C. Sturm
J. Budzileni

President Bradley: If there are no questions, we'll take a short break and reconvene back here in 15 minutes.

Recess

Mr. Lileikis: Bob Carter will introduce the next presentation.

Mr. Carter: Cliff Shoemaker began his career with the engineering department of the Union Pacific in 1967 after he completed studies at the University of Nebraska at Omaha, majoring in engineering and business management. Cliff's current responsibilities include administration of all highway-rail projects as well as industry development projects for Union Pacific's 23 state system.

Cliff is current Chairman of the Association of American Railroads Grade Crossing Safety and Trespasser Prevention Working Group; Chairman of Operation Lifesaver's national Program Development Council, past chairman of AREA's Committee on Grade Crossings; a member of the Transportation Research Board's Committee on Grade Crossing; Texas Transportation Institute's Transportation Advisory Council; Operation Lifesaver, Inc. Board of Directors; Roadmasters and Maintenance of Way Association and the American Bridge and Building Association.

He is also involved with several other national and local communities involved with highway-railroad safety, research, construction and maintenance.

Please join me in welcoming Cliff Shoemaker, director, industry and public projects for the Union Pacific.

GRADE SEPARATION PROJECTS

Cliff Shoemaker

Director Industrial and Public Projects
Union Pacific

On our property we have a matrix organization where, for example, our structural department is not the entire process. It's divided up between design construction and maintenance. So for a bridge project the structural group will review the plans, but then we send it over to your estimators which is a separate group to do material and force count estimates. My group

in the public projects arena handles the agreements, handles the negotiations with the states to make sure our bridge department gets their crack at it, and our consultants get their crack at it, and the estimators get their crack at it. Our law department also looks at the agreements and so on. We are generating anywhere from 200 or 300 grade separation projects a year plus approximately 2,000 crossings projects in the hopper at any one time so it's very easy for things to get lost in the shuffle. So, again, the communication coordination is absolutely paramount to these projects for approval to make sure you don't lose them in the cracks.

Again, the governing guideline from a federal standpoint is a federal policy guide. We have a standard drawing that shows our preferred clearances. Basically we send that to the state and say we will have those clearances which include 23 feet of overhead, minimum 25 feet to the nearest pier, provision for future track at 20-foot centers, certain grade requirements, and so on. If they can adhere to that standard on the front end it's basically a stamp off for us. Everything else becomes an exception. Likewise, if there is a walkway on an overhead bridge that would require it to be fenced just like interstate standards so people can't throw rocks and bee cans at the trains. We require splash guards on the sidewalks on the edges of structures if it goes over a live switching yard where we have people walking on the ground underneath it. These are the types of things that we get a lot of hassle about with the states. It usually gets dragged out and they need to get the thing approved so you sign off on it.

There are a lot of issues that come into play and having a good standard form of agreement and a good management process to keep on top of these projects is really paramount. With taking all those clues you can have a very successful program.

That's about it, Bob. If anybody has questions or comments, I would be happy to answer them.

Member: What liability issues are mentioned in the Federal guidelines?

Mr. Shoemaker: The liability issues aren't mentioned in the federal guidelines. That's intentional because we wrote the federal guidelines basically. It's kind of difficult to put a liability or a dollar value on a human situation that is absolutely there. The guidelines are such that theoretically if you put in a grade separation structure replacing an at-grade crossing, the five percent required share is based on the maintenance savings. That is on average what is computed out. If you take a set of signals out, for example, that's about $3,000 a year on average. Crossing surface is getting very expensive as you are all aware. We are up to $1,000 a track foot in concrete including the relay work and surfacing and aligning. So if you are looking at a double track crossing, 50 feet each, that's $100,000 all of a sudden. You get up there really quickly. So you amortize that over a 15 or 20 year life span plus $3,000 a year recurring signal maintenance costs and it ends up about 5 percent for a standard grade separation structure.

I might add the guidelines also provide for a theoretical amortization of cost. If you have a two-lane road and a single track facility and they want to grade separate, but they want to do it with a four-lane bridge with maybe some different wrap down points and off and on ramps and that type of thing, we are not required to pay for that improved facility if you will. We are only required to pay 5 percent of the theoretical structure that would have been built if it was a simple two-lane road single track structure. There is confusion on that issue, but it's very well covered in the guidelines. You might want to make sure that your public project guys are fully aware of that. If you see a grade separation project going in where it's a multiple lane facility replacing a two-lane facility, you are only required to pay up to 5 percent of the theoretical costs of a two-lane facility

However, again, in certain negotiations we very seldom have put in a grade separation without closing more than one crossing. We go out with the state as soon as we hear there is a new project concept going on to get involved with their consultants and see what can be done to close several adjacent crossings. Sometimes the infrastructure is in place to do without a lot of construction if you have parallel roads. On the other hand, sometimes you have to work with them and donate rights of way to put in parallel access roads on your properties to connect up

the side roads and force all people to use the grade separation. Then you get multiple benefits of the crossing closures and the liability that goes along with it and the savings and everything else.

We have had too many cases in years past and Gothemburg, Nebraska, comes to mind where they are finally looking at a separate structure. It's a double-track facility. Now we are in the process of building a third main line. About ten years ago the state paid for a new grade separation. We didn't pay for any part of it because they didn't close the crossing. But there are about six at-grade crossings in this town, put the grade separation in, and the only time they use it is when the train is actually occupying the crossings. Now they are going back and want to put in a second structure in the center of town. We said we are not going to participate in this at all unless it at least addresses the closure of several crossings. We are offering to pay 20 percent for those things. It's about a $6 million project. They are going to close at least four and possibly five of those at-grade crossings. We are going to donate some right-of-way and do a lot of other things to facilitate this project. It looks like we are going to be able to get rid of all but one crossing and that's an emergency crossing that they are going to keep closed to the general public but use for emergency vehicles.

This location is doing similar things little in a nontraditional way. For example, the Burlington Northern project at Grand Island or UP's relocation project in Hastings in the last couple years. It stated off essentially as a rail problem at Grand Island. That was the heaviest at-grade crossing in the world in terms of tonnage. The Burlington Northern was junior to us at the interlocking. The BN got with the state and was able to put in several grade separations plus lift their track up and over the UP and eliminate about six or eight crossings on the BN main line.

On the UP relocation project at Hastings, we were junior to the BN interlocking at that location. It was about a $35 million project but we relocated five and a half miles of main line, put in three highway structures and one railroad structure where the BN eliminated 13 at-grade crossings in the process and raised their train speeds from 30 miles per hour to 50 miles per hour with no stops and no crossings. It's all double track with extended sidings. It was generated as a grade crossing project to start with, but it kept growing and growing and finally it got justified on a capacity issue, on safety issues, and liability issues, et cetera.

Don't just take a grade separation at face value. Start looking at the other options out there including closures, and operational improvements.

Another example is at Cozad, Nebraska. There we have an existing double main track and we are putting in a third main track. We had a center siding of about 13,500 feet long but it had two at-grade crossings in it. We actually took it out of the timetable as a siding because we couldn't block those crossings. We went in with the City of Cozad and the State of Nebraska and were putting in a grade separation and closing those two crossings, paying the local match again, but what we are doing is getting a free 13,000 foot siding back that we can use to pass trains on. Again, what started off as a little grade crossing problem ended up in a multi-million dollar grade separation crossing closure of corridor project. If you use your imagination, these things are really paying out.

From a capacity standpoint, we are finding that crossing closures at grade separations are actually cheaper than building new track in some cases. You can be talking about several millions of dollars. For the same amount of money or less, quite often you can get more use out of your existing facility by closing crossings, grade separations, and doing corridor studies of that type. You are getting the best of both worlds. You are getting your capacity built up plus you are getting rid of crossings, the liability, the maintenance, the crossing blockage issues and all the things that go along with it. It's really an eye opener.

Part of the goal that I set for my managers in the job agreement we have each year is to close a certain percentage of crossings. They can do that by any means. It can be flat out closures which are tough or through grade separation consolidations. It's a lot easier to sell a

crossing closure if you are putting in a grade separation. They can see the obvious benefits to it. This year so far we have closed about 200 public crossings and probably about one third of those are associated with grade separations. It is a very workable process. Again, those are all contingent upon having federal funding available. If you are keeping track of the legislation right now, it is at risk. Anything you can do to support your legislative folks in Washington or your state is appreciated. We can use all the help we can get.

Member: What about the flip side where you get a grade separated crossing or grade separated facility and the state wants to go back and add an at-grade crossing.

Mr. Shoemaker: We are seeing more and more of that. What has happened over the last, say, 50 or 75 years with the interstate construction is a lot of those earlier structures were put in on a primary highway or what was a fairly important road at that time. Then through interstate and other freeway construction the traffic is diverted away from those facilities. It would not warrant a new grade separation now if it was a brand new project. So what they want to do is take the old grade separation out and put in an at-grade crossing. We usually fight those unless we can show that it just doesn't make any economic sense to insist they go back to a grade separated facility.

Say you only have 100 vehicles a day and it's a low density rail line. What we have done in those cases is use that as a tradeoff if you will. At certain locations we will agree as long as you keep this crossing, maybe close an adjacent one, but let's take bridge replacement money that is available and put that someplace else where it's going to do more good.

Now certainly liability becomes an issue there so we ask them to initiate the project and have them order us to do that. It's kind of a key thing. You can't just voluntarily agree to that because sure as heck in the first action some plaintiff will pick up on that. But we have to be reasonable with the state folks, too. There are always tradeoffs. We have found that by negotiating with them and saying, okay, you have got bridge replacement money for it, let's take that money and build a new bridge or do something else someplace else where it's going to have more need and agree with them to take that structure down if it's not needed.

In a lot of cases, the ADT traffic count has gone down from, say, 10,000 from 50 years ago to 500. Maybe it's on a line where the rail traffic is diminished somewhat over the years for whatever reason and it simply doesn't make sense to put that kind of money back into a separation at that location. But you need to have your legal papers covered and your tracks covered and take that money and use it someplace else on the property because it can be done.

Thank you. (Applause)

President Bradley: Thank you very much, Cliff, on an excellent presentation. Bill GeMeiner will introduce our next presenter.

Mr. GeMeiner: Our next presentation will provide an overview of current codes, industry standards, and future regulations concerning above ground storage tank, upgrades, and operations.

Joe Hartman is vice president of both Hartman Management Services and Hartman Management and HMS Publishing. Joe holds a Bachelors degree in industrial engineering from Northern Illinois University and is a member of the NFPA's Automotive and Marine Service Station Safety Code Committee. He is also an active member of the Petroleum Equipment Institute, the Midwest Society of Professional Consultants, and the American Society of Petroleum Operation Engineers.

HMS has been consulting in the petroleum equipment industry for 35 years. Their primary business is the design and construction of fuel handling systems and training of installers, inspectors, and regulators.

HMS publishes a monthly trade magazine called Petroleum Equipment and Technology and the Liquid Storage Tank Technology an Independent Study Course. Both publications are geared towards communicating current technical information related to the installation of above ground and underground fuel storage systems.

Won't you please join me in welcoming Joe Hartman. (Applause)

UNSCHEDULED TANK REPAIRS

Joe Hartmann

Hartmann Management Services

Good afternoon, guys, and welcome to Chicago. I hope you are enjoying your stay. My name is Joe Hartmann. I am a petroleum operational engineer for Hartmann Management Services. Our primary business is the design and installation of above ground and underground storage tank for vehicle fueling.

In the last couple of weeks I have had an opportunity to see a number of speakers, anybody ranging from Barbara Bush to Bill Cosby to Dick Vitel and Larry King. Each one of them had a message that they wanted their listeners to hear – except for Larry King. He just kind of got up and talked for half an hour about whatever he felt like. But I figured I had better have a message for you.

Basically as I was preparing for this presentation what I came up with is when it comes to above ground storage tanks and fuel handling, you guys are on your own. There are two reasons for me to say this. The first one is that each one of your facilities is different. You have a different number of storage tanks. They have different capacities. You are pumping different volumes of product through your facility, and you are all located in different geographical areas.

The second reason is from what I have found there is no one set of rules and regulations that govern above ground storage tanks. There is a variety of existing statutes, recommended practices, and trade practices, but there isn't any one set of rules and regulations like we have with the underground storage tank world.

In 1988, the EPA got together and established some rules that work as guidelines for underground tank owners as far as what they needed to do to upgrade their tanks and what they had to do for continuing operations and reporting requirements. But it's coming. There is going to be above ground tank rules and regulations promulgated by the EPA and the reason is because of a few recent problems. The first one was in 1988 when a Shell oil refinery had a spill from a 12.5 million gallon above ground tank. It had a floating roof and the roof drain had a failure that caused a 400,000 gallon spill into the environment and that contaminated the area's drinking water.

The second horror story is with a National Oil and Chemical 4 million gallon tank. This was one that was remanufactured and actually relocated to a new facility. The first time they filled it instead of hydrostatically testing it with water they decided to use fuel. It was in the middle of winter and they had a brittle fracture. The tank split and they spilled a million gallons into the environment and eventually it made its way into the Ohio River.

One that occurred much more recently and much closer to home is the class action suit filed by residents of Wyoming against Amoco Oil and a dry cleaner and a railroad yard. None of these operations are in business anymore, but residents are suing them because of years and years of spills, overfills, and contamination. They are going after them not only for cleaning up their property, but they are also saying it's devaluating their property. So they are going for compensatory damages as well.

So if you are in charge of your facility, it lends credence to the idea that you have to put together a business plan that establishes accountability for the product you are storing and the product you are using.

You want to have a first line strategy for release protection. You want to establish a baseline and look at the variances that are acceptable in the product that is stored.

With regard to future above ground tank regulations what I would expect is that they would mirror what we saw with the underground tank regulations. You will see requirements

for other fill protection, monitoring and release protection with your above ground tank, inventory control, and then cathodic protection both externally and internally.

I want to talk about four areas as I go through the standards. There are a huge number of standards and recognized practices that govern the installation and ongoing operations for tanks. I just want to introduce you to the organizations that are coming up with these standards and have been established already. I put together some cheat sheets to help you decide which of the standards are geared towards you. I don't want to go into them in detail because some of them don't pertain to your particular situation.

The first group is ANSI and ASTM. They both have standards for the construction of tanks. EPA has a lot of standards that deal with handling fuel. In this area the field fabricated tanks and welded steel tanks standard 620 and 650 both relate to the type of tanks that we are talking about. Two standards, 653 and 2610, both have to do with the design and also the operation and maintenance and inspection of the above ground storage tanks. Towards the end, I am going to get into 653 a little bit and some of the inspection requirements required. RP 1102 is one that is geared towards specifically underground piping going underneath railroad tracks and highways. So that would be pertinent to you.

Right now, as a preface to the new EPA rules and regulations, the EPA is developing a prevention release protection matrix system. They are in the process of working on it right now. It should be out by the end of the year. That is geared towards helping you to decide which type of release detection method is appropriate for your size and type of tank. EPA reference is in NFPA quite a bit as far as the size of tanks, the spacing between tanks, the distance setback requirements from property lines, from roadways, and from buildings. Maintenance service stations safety covers operational issues. If you are from the California and west coast area, the International Fire Code Institute has a uniform fire code. They set a standard specifically geared towards cathodically protecting tank bottoms.

Under the Petroleum Equipment Institute we are getting into the smaller tanks up to 50,000 gallons. STI and UL all have standards that address those. UL has a new one right now that it has geared towards fire protection tanks and tanks of this type.

The Oil Pollution Control Act of 1990 requires procedures to prevent contamination into waterways.

I don't think the Clean Air Act as far as your fuel storage is going to have too much of an impact on you. However, the Clean Water Act of 1973 established through storing a way to maintain integrity of the nation's waterways.

CERCLA administers a superfund. That includes through the freedom of information what reporting requirements you have to the product you store and if there is a release, what was released.

RIPRA regulates above ground storage tanks. The National Pollution Discharge and Elimination regulates storm water runoff.

Regarding OSHA and the state regulatories, the state always has the option of going more stringent than the Fed. That's the way the regulations work, too. They can be more stringent, but they can't relax the federal rules. So you have to check with them if you are going to do any work in that area.

I put together some sheets for you. One talk pertains to the standards whether it's construction or corrosion control, leak detection, or piping. It is a list of the standards that apply to each particular area. I have copies in the back of the room if you want to have those.

Going at it from a different direction, I have a chart that looks at the products stored, the size of the tanks, and it also tells you which regulations apply towards your particular situation.

Another way of going about this is with a flow diagram. If you follow this from the beginning to the end each step of the way tells you which one of the NFPA documents and paragraphs apply to your specific situation. Whether it be spill over, fill protection, setback require-

ments or those types of things. Eventually you work your way down from the maximum capacity and things like that.

So those are some aids as far as helping you get through determining which rules and regulations apply to your particular situation.

STI put together a comparison of the different codes that govern the smaller above ground storage tanks. In this particular comparison they highlight what the difference is between the two codes and try to decipher some of the things in there. There is a lot of conflict between NFPA, both uniform fire codes and in most organizations. So, again, the geographical area that you are operating in will determine what the requirements are to your upgrades and tank installations.

The EPA spill prevention control, a counter measure program, requires just about everybody to have an SPCC plan. We went through and took a survey of all the above ground tank owners to find out who they were and what kind of tanks and storage capacities and volumes they had. The second phase of this will be coming out with the technical and administrative requirements or the equipment that is required for your type of tank, whether it's floating or fixed or that type of thing. Regardless, it does require you to have the SPCC plans which I know you probably already have for your facility, but I am going to come at this at a little different angle. I like to think of a SPCC plan as like a contingency plan. It gives you the opportunity to take a look at your operation and your facility to define exactly what you have and then establish some set procedures in the event of a release. So you have proactive thinking rather than reactive thinking when you are taking care of either a slow spill or more of a catastrophic spill like we had with the Ashland oil problem.

Basically, as I said, with so many facilities, when you go through and determine whether or not you are required to have a SPCC plan basically I think it's safe to say pretty much everybody in this room is required to have a SPCC plan. The plan should cover spill prevention. It should describe the physical facility or plant layout, document the number size of tanks and products stored, emergency procedures, and predicted flow of the released product if you have them both in common. They want to know where the product is going to go once it is released. It would outline the need for diking. It would outline requirements for integrity testing usually every five years or other leak detection requirements. Then also you outline the inspection requirements.

As far as security, most of your facilities will typically be in industrial areas away from the general public. Then you take those tanks and you stick them way back in the corner somewhere so they are out of the way of the operation. However, that puts them in a prime area for tampering. So you have to protect the tanks, the pumping equipment, the drains and all that, against vandalism. Put fences and gates around it. If you don't have constant guards for the facility, you need to have a locking gate. You lock the flow and drain valves in a closed position. Lock starter controls on all pumps. If you are receiving deliveries by transport you might want to go to an automated delivery system where they require the transport driver to function with a pin number before he gains access to the pumps to off load.

If you are not going to be using your facility for more than six months we recommend blanking off loading and unloading connections. Also don't forget about facility lighting especially if you are receiving deliveries throughout the night.

Brittle fractures, again, the type of thing that happened with the Ashland oil problem. If an above ground tank undergoes a repair alteration or change in service the owner must evaluate the risk of failure of brittle fracture in accordance with EPA 653 so the onus is on you.

The SPCC requirements also include spill recording, time, location, and source of the spill, what product was spilled, why did it spill, the cause, hazards of the spill, if there was any personal injuries, corrective actions taken, and then a contact person for the facility so they know who to call.

Finally, we have equipment in operation. Things to consider with the operational considerations are maintaining and installing or designing the tanks for the product that you are going

to be handling, the pumping system, and the piping. Whether you want to go with above ground or below ground pumping, there are different considerations for each.

Other areas to consider are fire protection and safety and general maintenance and monitoring. I will also talk about tank leak detection and inventory control and then comprehensive inspection and maintenance programs.

One of the things to keep in mind with the current set of rules and regulations is that they weren't put together by the EPA. They were put together by fire inspectors, regulators, and these types of people. So what you will find throughout all the documents, all the literature that is out there right now, is that they are more concerned with the safety of your personnel and their personnel than they are whether or not you're impacting the environment with your spills. So you will see that throughout the documents. For example, with dike construction it has to be 100 to 110 percent of the largest tank's capacity. They still show them as materials of construction. Earthen dikes are still allowed as well as clay, concrete, geotextile fabrics, and Gunite. If you are going to put in a new facility right now, Gunite or some type of geotextile fabric is a very good product to use for your dike because of their high permeability or lack thereof. Poured concrete or reinforced concrete with a sealed floor that is resistant for the product it stores is probably one of the best ways to go. The dike has to be able to withstand the pressures when filled with water and of sufficient height to accommodate wave action, but you don't necessarily need it designed for a catastrophic release.

Again, from the fire protection standpoint, the highest a dike can be is six feet high. If it goes over three feet, they want a two foot wide top on the dike. If it is up about six feet or so, they want a method of getting in and out of the dike. You also should give some consideration to whether you want your pumping system to be inside the dike or outside the dike but certainly you have to have a way of shutting it off from the outside.

Fire suppression equipment is also covered in NFPA. Again, we want to protect against vandalism.

Regarding monitoring and maintenance, inventory control is a first step as far as establishing release protection. You want to be able to take multiple measures throughout the tank. With these above ground tanks there is a huge surface area compared to underground tanks. It's a much smaller surface area to measure. Also there are wide variations in the temperature throughout the tank. The density of the specific gravity of the product and the water bottoms are all things for which the system must be able to compensate. Some of the systems now are capable of building traffic tables over a period of time from statistical analysis and they are much more accurate at this time.

For the types of tank gauging systems, the float and tape is one that is probably pretty common and well known. It's a spherical motor where you actually have a motor at the top of the tank and the impedance is measured down to a gauge and then off to a side.

An inductive flow which basically acts like a magnostrictive probe down in the tank and the level of flow tells you at what level the product is.

We are starting to use radar and pneumatic hydrostatic methods of tank gauging.

In our designs, we try to get as much redundancy in the leak protection systems and in overflow protection systems as we can. If you have single system and it shows a leak it can be very expensive once you drain the tank and find out it really isn't leaking. It's nice to have a backup or sanity check to make sure that the thing is actually leaking before you start pulling it apart.

With regards to leak detection, if the smaller tanks are unsaddled, then obviously you can visually inspect them. A lot of the major oils are going to double wall tanks. They would then monitor the space between the two floors of the tank for any released liquid. Soil gas monitoring, drilling holes around the perimeter of the tank and taking vapor samples to determine if there is any release. The problem with this is if the facility has been around for a while, you get background contamination and reliability of the system is suspect.

Another method of release detection is by introducing tracer chemicals into the product stored and then you take vapor samples from those same type of wells from around the perimeter of the tank. If you see that tracer chemical then you have a better handle on whether or not you actually have a release or if you are looking at background contamination.

I just read an article on the topic of lightning prevention and it was very interesting. It found that the most frequent cause of ignition in above ground tanks is because of lightning. Before this, I always thought it was static, but now I guess I am looking at it differently. The key to preventing any fires due to lightning is preventative maintenance. In a properly functioning system, it would conduct the electricity through the tank shell to ground without forming spark or building the heat sufficiently enough to ignite a fire inside the tank. One tip that they had in this article was fixture of tanks. They preferred installing pressure vacuum vent rather than flame arrestors because flame arrestors had a maintenance problem and they could become clogged. On the other hand, with pressure vacuum vents from my experience the valves can get stuck so there's another thing to look for on your inspection. We have to take a look at those every once in a while. Avoid storing oil over products like crude oil in tanks because they settle out and have a flammable atmosphere at the top of the liquid. With external floating roof tanks, visually inspect the lightning trunks regularly and bolt shut the compartment covers. The bolts serve as a conductor which is something that you want. If they are not bolted tight then the lid can blow open and you can get lightning in the tank that way. Also you could get a static release if the tank blows open. Inspect the pontoons and keep the floating roof five feet below the tank rim during storms. That way the roof of the tank is most likely to be hit from lightning.

An internal floating roof tanks should be inspected frequently to make sure the roof is still floating. That seems pretty obvious to me. Make sure there is no liquid on the roof. Visually inspect lightning trunks again and then check them frequently.

For cathodic protection for the tank bottom, you want to be able to protect the tank bottom both externally and internally. One way of doing this is by adding anodes to the tank. Basically the anode is a sacrificial metal that prevents the tank bottom from corroding. The problem with anodes is you usually need so many of them that they end up being cost prohibitive.

Another way of going about that is to add an impressed current system where you actually put a current into the tank. That turns the tank into a cathode and protects the bottom of the tank. The nice part about the impressed system is that it's adjustable. If it's not doing its job you can always turn it up. It can be used to protect a large number of tanks. On the downside, if you lose power or for some reason the unit goes out, then you lose your cathodic protection. So there is a maintenance issue still there.

At the bottom of the tank, if you are taking your tank down for inspection anyway, something you might want to take a look at is lining the tank. This is most useful where corrosion damage is rampant and it does not weaken any specific section. If it does, then you repair that. We typically put 100 ml coating of polyester or epoxy on the bottom of the tank and up the side walls of the tank a couple of feet so that if there is water on the bottom of the tank then you don't get corrosion on the side wall. For lining, interestingly enough, that's all you needed to do in underground tank regulations to consider a steel tank cathodically protected. It does a nice job of protecting from internal corrosion, but I don't think it does a whole lot for external. So you may want to go with some type of a redundant system there also.

The last thing I want to talk about is inspections. They are typically broken down into four categories. Routine external inspections should be done every month. Formal visual external inspections are done by a qualified inspector who is qualified through either training, a TE type of person, or through experience. This is typically done every five years. Ultrasonic shell thickness testing should be done five years after the tank is originally installed. Then the period between testing depends on the corrosion rate you have determined through that test, but it's a

maximum of 15 years if the corrosion rate is unknown. For internal inspections, again, you go back to that corrosion rate to determine how often it should be done. It should never be any more than 20 years. If the corrosion rate is unknown then EPA recommends ten years.

The types of things that we are looking for are EPA 653. There is an appendix C that is a sample checklist for internal and external inspections. It is about ten pages long so it's a very detailed checklist. It helped me a lot as far as determining what should be checked when you are going around. Basically what we are looking for are leaks from the shell of the tank, any shell distortion, or any bulging towards the bottom of the tank. You want to check for any signs of corrosion. Check the cathodic protection system if you have the impressed current system. You want to make sure it's operating properly. Check the grounding system, the shunts, mechanical connectors, and cables. Check the condition of the foundation for any spalling or any cracks in the foundation or any settlement that you should not be seeing. Check the painted coatings, insulation and other appertenances like vents that we talked about.

I do want to put up some of the references I went through to put this together. The University of Wisconsin has a course geared towards above ground storage tanks including the construction and operation and maintenance. Thompson Publishing puts out a guide. I put some brochures for the guide in the hallway. It's an exceptional guide. It goes state by state and then also federally. I don't work for them and I don't get paid by them, but I do think it's a good book. If you are in charge, I think it's one that you ought to have. Also, Automatic Tank Gauging Systems from Barkman is another reference I used.

(Whereupon there was a slide presentation)

I consider these pictures the good, the bad, and the ugly. This is the ugly. This is actually an abandoned off-loading area. The pumping is inside this building. You can see staining and things like that from years and years of fueling. You can see the tank that is filling. It is no longer in operation, but you can see that it is buried back in the corner like I was talking about. It's over grown. Believe it or not there is a dike in there somewhere. From a fire protection standpoint it would be very difficult to go in and try and put out a fire in this area. That is it for the ugly.

This is the good. To replace that system, this is the off-loading area. You can see that the concrete is adjacent to it. A collection point goes down to an oil water separator and then to the facility's treatment plant. You can see the off loading arm off to the side.

One of the things that you have to keep in mind along with these inspections is, as I mentioned, static discharges. There was just a case down in Florida where there was no continuity between the end of the nozzle and ground and because of that they had a fire. It was actually diesel fuel that built up more static than even gasoline and blew a truck across the street and killed a guy. So you want to make sure in your inspection that you also check the continuity between the end of the nozzle and ground.

Mr. Lileikis: Thank you, gentlemen. Our next presenter is Dan Dalton of David L. Holt Company.

The David L. Holt Company is one of the few nationally recognized firms that specializes in flame straightening steel.

Dan has extensive experience in railroad work from derailments especially at BN where they are employed nearly full time.

Dan has been working with flame straightening steel for about 16 years, the last 10 with David L. Holt. For the past three years, he has been running the operations of the company.

FLAME SHORTENING I-BARS

Dan Dalton

David L. Holt Company

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Mr. Lileikis: Thank you, Dan. Our final presentation this afternoon is CP's Bridge Changeout at LaCrosse, Wisconsin. The presenter is Steve Hill, manager bridge and structures construction for CP Rail and he will be introduced by President Bradley.

President Bradley: Welcome back to part two of the Steve Hill show. Steve is going to give us our final presentation this afternoon.

Steve began his career in 1972 as a section laborer for the UP Railroad putting his Bachelors degree in history to good use. He then moved to a survey crew and finished a degree in civil engineering in 1977 from the University of Kansas. Steve then spent two years at the Illinois Central and in 1980 hired on with the Soo Line as an office engineer. He transferred to Chicago in 1987 as an assistant regional engineer just after receiving his MBA from the College of St. Thomas.

Steve then became assistant division manager in 1991 and returned to Minneapolis in 1994 as manager of bridge and structure construction. So you can see all of his track background finally gave him enough good background to get him into the bridge part of railroading. (Laughter)

Through the last reorganization, his title was changed to manager of structures. Steve is a registered professional engineer, a member of the Bridge and Building Association, past president of the Roadmasters Association, and a member of AREA.

Steve will be talking about CP's bridge changeout at LaCrosse, Wisconsin.

CP RAIL BRIDGE CHANGEOUT AT LACROSSE, WISCONSIN

Steve Hill

Manager Bridge and Structures Construction
CP Rail

Good afternoon, ladies and gentlemen. As you have heard, I will be describing the changeout of a truss span with a through plate girder span. What we will go over is a bit of the history of how the bridges came to be here, why we needed to change the one we did, and a somewhat unique opportunity to get a good look at how 90 plus years of life and railroad loadings affect pins in such a bridge.

The LaCrosse & Milwaukee Railroad originally built their railroad into LaCrosse from the east in 1858. In 1872, the St. Paul & Chicago Railroad built from LaCrescent across the Mississippi River from LaCrosse to St. Paul. In 1873, a ferry service was established to move cars between these lines. In 1876, the first bridges were built here by the Chicago Milwaukee

and St. Paul, connecting the railroads. Swing spans were constructed over the Black River and the Mississippi. The current bridges were built beginning in 1902.

What we currently have is a series of four bridges from the Wisconsin shore to the Minnesota shore. The total distance is about 7,200 feet, of which about 3,500 feet is bridge structure.

We have a bridge over the Black River which is four 69 foot deck girders on the east approach to a 310-foot truss swingspan and five 64-foot deck girders to the west. Next we have a bridge with six 54-foot deck girders to 163-foot Warren truss and six more 54-foot deck girders over what is called Frenchman's Slough. The east channel of the Mississippi is crossed by one 25-foot deck girder, five 146-foot Warren trusses and a 40-foot twin deck girder. It is one of these trusses that we changed out. The main channel of the Mississippi is crossed with one 40-foot deck girder, two 162-foot Warren trusses, a 247-foot camel back through truss, a 357-foot through truss swingspan and a 75-foot deck girder. All of these spans are seated on the 1876 vintage masonry piers from the original bridge here. Some of these have been encased in concrete jackets over the years.

The eight shorter trusses all have an equal number of panels which becomes a contributing factor in load transfer stress at the center pins of the lower chords.

We had originally considered replacement of these trusses beginning in 1992. It was decided that further study was needed to determine the proper sequence of replacement. With this in mind, we began a series of acoustical emission testing in 1994. This involved placing resonant acoustic transducers on each I bar on the head near the pin connection.

The system was connected to a computer for the data gathering which was on a barge below the bridge. Before testing, the system was calibrated to screen out the background noise. A test consisted of locomotive and eight loaded ballast cars all of which had been weighed. Passing trains were also used in the testing.

Analysis of the data produced indicators of fatigue cracking and stress intensity where present. Fortunately, there were no cracks identified. However, during the testing our pump repairman, Andy Anderson, who was providing the track protection, noticed a strong pounding at the L3 pins on the west truss span on bridge L4A while a train was passing. Closer inspection showed that the pin was moving and hammering against the lower chord member. That was on a November 7, 1994.

By the 22nd, we had fabricated and bolted on thick steel plates against the edges of the nut to take the impact instead of the chord. We then dusted off the design for a TPG span that had been done in 1992 and altered it to fit this location.

The new bridge was designed for Cooper E-100 loadings and weighed about 278 tons including the deck. The old truss span rated out in the low E-60s, given its condition. It weighed about 169 tons including the deck.

Dominion Bridge of Winnipeg was awarded the bid for fabrication on January 6, 1995. Now the real fun began. We had to get permits for this. Simple? Should be just the Corps and the DNR? You would think so. However, several other agencies felt they had to contribute. They were:

Wisconsin DNR
Minnesota DNR
US Army Corps of Engineers State Historical Society of Wisconsin
Minnesota Historical Society
US Fish and Wildlife Service US Coast Guard
Root River Soil and Water Conservation District

We had to do a survey for Higgins Eye Mussels for the Fish and Wildlife Service.

This was all after a long discussion as to which state we were in. This took until September 10 to complete all the permitting.

Meanwhile, we had awarded the bid for erection to Lunda Construction and Hi-Boom Erecting on June 8. That was the same day the steel was shipped from Winnipeg. They were finally able to begin the assembly on September 14 with the placement of false work adjacent to the truss. Assembly of the span on the false work began on the 29th and took two weeks.

We had to work very closely with our dispatching center to coordinate the work window we would need for the change out. We had to do the work on a Tuesday or a Thursday which was when Amtrak train #8 originates in St. Paul and is not the through train from Seattle. Plans were made to buss passengers from St. Paul to LaCrosse with the equipment being deadheaded down the night before and placed at LaCrosse for an on-time departure from there at 1100 hours. Other trains were to be held and we were to be given the track at 0500 with the scheduled finish being ahead to Amtrak #7 which was due out of LaCrosse at 2012.

Early on in the morning of October 17, we had two trains to clear. UP 3486W cleared at 0510 and the deadheading Amtrak #8 equipment cleared at 0520. The crews arrived in their hi-rails at 0530 and we held a short safety meeting. The rail came off first and cutting of the wind bracing began about 0620.

As pieces were cut, they were removed by the crane on the barge and set on the shore for later handling.

The cutting was done using oxy-lances. These are three-quarter inch diameter pipes filled with several manganese rods. They are 10 feet long and are connected to an air line through which oxygen is pumped. The end is lit with a cutting torch and the oxygen flow is turned up generating an extremely hot cutting tool. Each rod lasts about five minutes. But in that time you could cut through a lot of steel.

The floor system was cut out and lowered to the barges below. Once the floor system was removed from the east half of the truss, the truss frame itself was cut and removed leaving the remaining portion supported by false work. The entire east half of the bridge was removed by 1135 with the remaining portion gone by 1440.

The tops of the piers were prepared by removing the old bearings and placing a high strength grout to form a level surface for the new bearings. While this was being done, the 40-foot DG span on the west end was lifted out to allow the new span to be rolled in. Block and tackle were connected to the air winches at each end of the bridges and a roll in on Hillman Rollers began at 1640.

The move was finished by 1755 with only a minor delay when one of the winches came loose and had to be resecured. At 1840 the new bridge was in place and down on its new bearings. The span was moved over with the ties in place so only the rail had to be restored. While this was being started, the 40-foot DG was set back in place at the west end.

The track work was completed at 2010. The form D order was removed at 2025 when the last of the track equipment was in the clear and Amtrak #7 crossed the new span at 2034. He had been a few minutes late into LaCrosse so we did not delay them.

The nice thing about a project like this is that it gives you an opportunity to judge the life expectancy of the other spans based on the condition of the key elements of the span you have removed. In this case, the key elements we were concemed about were the pins. They were very difficult if not impossible to test in place and have a high degree of confidence of the real condition.

Our research and testing department took apart all of the pin connections and tested the I bar heads and the pins themselves. One thing we discovered very quickly was that the steel used in these members was of a higher strength than was expected. We had no records telling us the type of steel used here in 1905. For the ratings of the other trusses we had to assume a 30,000 psi steel to be conservative. It turns out that the steel tested out at about 46,000 psi. Some of the members tested even higher. Therefore we were able to up our ratings of the other spans using a higher strength for these members.

What was found greatly relieved our concerns about the other truss spans. The pins, while showing some uneven wear due to loading differentials in the eye bars were in reasonably fair condition. The eye bars were closely examined for fatigue cracks and none were found.

Overall, though, we still have an aggressive plan for replacement and repair of the remaining truss spans, we have a more comfortable grasp of the likely conditions and life expectancy of them.

In closing, I would like to thank Lunda Construction, Hi-Boom Erecting, CP's bridge, track, and signal forces, CP's field test engineering staff, and CP's dispatching office for their assistance in making this changeout and analysis possible. Thank you. (Applause)

President Bradley: Thank you, Steve. By the way, Steve, last year you did one presentation and this year you did two, so we are looking forward to three presentations next year. (Laughter) Thank you very much for your help.

Before you all leave, if you would please take some time and fill out the conference comment reports. There are also some forms in the back for special subjects for next year. We are hopefully looking to this group to volunteer their services for potential presentations.

With that, we will end for today. Don't forget the REMSA reception at 6:00 o'clock tonight at the Wellington Room. We are going to reconvene at 8:00 o'clock in the morning for the Joint Session in the Wellington Room. Thank you and have a good evening.

(Adjourn)

JOINT SESSION

Wednesday, September 25, 1996

President Bradley: I'd like to thank REMSA for hosting the reception and giving everyone the chance to socialize before going out to dinner. At this time, I'll turn the podium over to Dwight Clark.

Mr. Clark: Our first presentation this morning is Teamwork for Success in an Environment of Risk and Change and will be presented by Jerry Markbreit.

Jerry worked for the 3M Company for 38 years. As Trade and Barter Manager, he daily negotiated and traded millions of dollars of advertising, media time, materials, et cetera, with corporations throughout the globe. That position, unique in the business world, combined with his experience as one of only 15 National Football League referees, has given him the background to develop an interesting and worthwhile message for professional groups.

After officiating football for nine years, Jerry became a member of the Big Ten Football officiating staff. His most memorable games in the Big Ten include:

The 1966 Notre Dame/Michigan State National Championship Game (10-10) tie; the 1972 Rose Bowl game between Stanford and Michigan; six Ohio State/Michigan games, including the 1971 (10-7); Michigan victory when Woody Hayes stormed the field in the "first national trade."

He became a National Football League Line Judge in 1976, and in 1977 was promoted to NFL referee. He is the only referee to officiate four Super Bowls; Super Bowl XVII between Washington and Miami, Super Bowl XXI between Denver and the New York Giants, Super Bowl XXVI between Buffalo and Washington and Super Bowl XXIX between San Francisco and San Diego. 1996 will be Jerry's 40th consecutive season of football officiating and his 20th year in the NFL.

Jerry Markbreit wrote a weekly football column for the Chicago Sun-Times for several years while working college football; and in 1973 wrote The Armchair Referee published by Doubleday & Company. In 1988 his autobiography entitled *Born to Referee* was published by the William Morrow Company. His speech topic is "Teamwork for Success in an Environment of Risk and Change." Please welcome Jerry Markbreit.

TEAMWORK FOR SUCCESS IN AN ENVIRONMENT OF RISK AND CHANGE

Jerry Markbreit

NFL Referee
3M Company
(Retired)

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Mr. Lileikis: Our next presentation is one for which we asked AREA to provide a speaker. B&B/Roadmasters and AREA have been exchanging speakers for the last couple of years. This year, the selection is on retaining walls and the presenter is Bob Lohnes from Iowa State University.

Professor Lohnes earned a Bachelor of Science degree from Ohio State University in 1959, a Master of Science degree in 1961 and a Ph.D. in 1964 from Iowa State University. He served as assistant professor of geology at Wisconsin State University in 1964 and 1965. He returned to Iowa State University in 1965 and was promoted to professor of civil engineering in 1974. Professor Lohnes spent one year as a visiting professor at Middle East Technical University in Turkey. Currently he teaches and conducts research on geotechnical engineering, foundations, and applied geology.

He is collaborating with a structural engineering faculty at the University of Edinburgh, Scotland, on stresses imposed by granular materials on the walls of silos. He has authored over 60 publications in journals and proceedings.

Please join me in welcoming Professor Lohnes.

RETAINING WALLS

Bob Lohnes

Iowa State University

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Mr. Lileikis: Thank you, Bob. Our next feature this morning is Mitre Rails on Movable Bridges. The speaker is Theresa Galloway, director structures maintenance for CSX.

Theresa received a Bachelors Degree in Civil Engineering from the University of Pittsburgh in 1976, where she had a teaching assistantship and was a member of Chi Epsilon engineering honor society.

She received a Masters Degree in Business Administration from Marshall University in 1987 and possesses many training certificates in Storm Hydrology and Hydraulic design. She has also attended Brigham Young University, University of Wisconsin, and Jacksonville University.

In 1977, Theresa started with the Chessie System Railroad as a structures inspector. In 1979, she began working in the bridge design office and held positions as designer, project engineer, structures engineer, and senior project engineer.

In 1986, she relocated to Jacksonville as a result of a merger and since 1994 has held the position of director bridge maintenance.

Ms. Galloway holds memberships in the American Railway Bridge and Building Association; American Railway Engineering Association and AREA Committee 15, Specifications for Steel Structures; Heavy Movable Structures and Board of Directors, Registered Professional Engineer; Panel - Recommended Specifications for Movable Highway Bridges; and National Research Council, Transportation Research Board.

Please join me in welcoming Theresa Galloway. (Applause)

MITRE RAILS ON MOVABLE BRIDGES

Theresa Galloway

Director Structures Maintenance
CSX

Good morning. My name is Theresa Galloway and I am a civil engineer with 20 years experience in the inspection, maintenance and construction of railroad bridges. I am now employed as director of bridge maintenance at CSX Transportation located in Jacksonville, Florida.

The examples that I relate in these pictures are from my own experience. An exhaustive research and benchmarking of railroad practices and policies is not represented.

CSX Transportation has approximately 20,000 miles of track passing through 20 states and Canada with about 10,000 bridge structures. Of these, 58 are movable bridges. Bridges are designed for a combination of load conditions. Bridge decks and rail systems must also be designed to safely carry these loads.

My subject today is "Mitre Rails on Movable Railroad Bridges." As a member of ARBBA and AREA, I very much appreciate this opportunity to address you.

Highway traffic can travel over steeper grades and have more fixed bridges over navigable waterways.

Railroad track surface will hold a flat grade and the least curvature wherever possible for the engines and car consists carried. This minimized the resultant driving and braking forces acting upon the rail, subgrade and structures.

Except in mountainous areas, railroad waterway crossings have a minimum clearance over the water. Along coastal areas, where track embankment approaches seawater level, tangent track and zero grade are encountered.

Railroads along the coasts and large waterways often have movable bridges to accommodate the needs of both rail and marine traffic passing. Movable bridges have numerous mechanical systems.

Swing spans will have a center pier and bearing.

A swing span pivots and is powered by center drive machinery.

Wedges drive to fix the bearings in place to carry train loads.

Rails at the intersection of the fixed approach and movable span reposition to permit opening and closing. Mechanical hydraulic, electric, and manual, systems used for power and control vary tremendously and are often unique to that particular system.

This is an example of a lift rail system on a through truss swing span located in Toledo, Ohio, crossing the Maumee River. Note the expansion joint on the approach span to isolate the lift rails from longitudinal force.

The lift rails are located on the swing span. Machinery under the bridge deck raises and lowers the mitre rails. Note the series of guide castings which align the rail when it is lowered into position for rail traffic. After the rails are lifted to clear the approach rails, the span can be rotated. Lift rail systems were one of the earliest types designs. A lift rail system on a deck girder swing span over the Alafi River is shown. An example of a lift rail system on a through plate girder swing span in Bradenton, Florida, is shown.

Another common type of old design is the "easer rail" system, also known as "rail tongues."

An unusual variation of easer rails at St. Joseph, Michigan, is shown here. The entire casting which surrounds the running rail is extended and withdrawn by throw rods.

An easer rail is short bar on the outside of the rail which is extended alongside the running rail to carry train loads over the separation between rails. The easer rail is pulled back by rods and levers to permit rotation of the swing span. The easer rail is guided by castings to align and secure it in place for rail traffic.

Easer rails were typically cast of 12 percent manganese steel, heat treated in conformance with ASTM Specification A-128 with a surface finish of 250 micro-inches in accordance with ANSI B46.1 specification.

The impact areas in contact with train wheels, the top and sides of the casting rail head, were to be explosive hardened to a Brinell hardness range of 370 +/- 5 percent.

The rails are still subject to wear and metal flow on the hammered ends. All new installations should be smoothed with a grinder regularly when first in service to remove metal flow during the work hardening process.

Per the signal requirements of the Federal Railroad Administration, rails which slide or lower to butt with those of the abutment or fixed span or easers that slide into position in the movable joint must be locked in proper alignment. Conley frogs are designed to be self aligning and are not required to be locked or electrically checked for alignment. They are required to be checked for vertical surface.

Limit switches control the driving machinery and give a positive indication on the position of rails and locks.

The hardened and alloy steels of movable rail systems are subject to tremendous impact with each axle passing at the transition from approach rails.

The Conley design of 12 percent Manganese rails provided a more standard design and manufacture of two piece rail locks for use on vertical and rolling lift spans. A double track bridge in Cleveland, Ohio is the up position shown. Note the V projecting from the toe of the bascule span. The two-piece Conley stayed fixed on the bridge deck and lifts and lowers with the bridge span. It is a passive system which is self aligning as the bridge is seated.

Note that two-piece conley at the transition to fixed span. Another type of Conley Rails is the three-piece system used on swing spans. An example on a bridge in Rigolets, Louisiana is shown.

The development and design of new systems continue to evolve. A new Ridex system manufactured by CMI Promex is shown.

This design uses a 4140 alloy steel, incorporates Pandrol clips and is in use on a number of railroads. Improvement of the design, manufacture, structural support and anchoring systems of movable rails is an ongoing process. The use of new technology and designs in combination with existing rail systems is working to reduce impact, better distribute loads and prolong the service life of rail systems and hardware.

Any questions or discussions are welcome. (Applause)

Mr. Lileikis: Thank you, Theresa. At this time, we'll take a brief recess and reconvene back here in 15 minutes.

(Recess)

Mr. Lileikis: Our next feature is CWR on Bridges and will be presented by Ken Bruestle, senior project manager for HNTB in Kansas City.

Ken obtained a Bachelor of Science degree in Civil Engineering from the University of Minnesota and is presently working towards a Masters Degree at the University of Kansas. He is a registered professional engineer in 15 states. Ken worked for the BN and its predecessor railroad engineering departments for a little over 30 years, primarily in bridge and construction specialization. He retired from the BN as director bridge engineering in 1994 and joined HNTB at that time.

Please join me in welcoming Ken Bruestle.

CONTINUOUS WELDED RAIL ON BRIDGES

Ken Bruestle

Senior Project Manager
HNTB

Introduction

I have been asked to talk about continuous welded rail, or CWR, on bridges today, but before we discuss the application to bridges, I am going to review some of the basics of welded rail.

Welded rail was introduced as a means of eliminating rail joints. A rail joint creates a weak spot in the track structure and an opening for wheels to pound. Removal of joints provides for a much stronger track structure and elimination of a wheel impact source. The familiar bolted joint is a simple way of splicing standard lengths of rail together in the field. For many years, the bolted joint was the only method used to join the pieces together.

The first installations of welded rail utilized standard lengths which were welded together in the field to create a continuous string. The weld procedures were slow and not very reliable, so the use of CWR was somewhat limited.

With the development of the modern rail welding plants which produced quality welds, and the special rail trains which could handle 1500' strings of rail, many railroads began to replace their worn bolted rail with continuous welded rail on the mainlines.

The 1500' pieces are joined in the field by a reliable weld procedure, so the track is virtually jointless, except at switches and other such locations. Today, most mainline rail is CWR.

CWR is placed in the roadbed in an unstressed state at so-called neutral temperature. Neutral temperature varies from location to location, ranging from about 90 degrees in the Northern latitudes to as high as the 120's in warmer climates.

Generally, auxiliary heat is required for the rail to reach neutral temperature, so the use of rail heaters is a common practice during installation.

I will now take a few minutes to discuss the mechanics of welded rail both in and out of the roadbed.

If rail is unrestrained, and is subjected to a temperature change, it will expand or contract at a rate proportional to the temperature change. The rail will always be in an unstressed state, if it is unrestrained.

When CWR is installed in the roadbed, it is no longer unrestrained. The rail is not allowed to move longitudinally. If the rail is now subjected to a change in temperature it will develop internal stresses. This stress is about 200 psi for each Fahrenheit degree of temperature difference.

The force that develops in CWR is dependent on the temperature change and the size of the rail. It is independent of the length.

At the discontinuous ends of CWR, the force in the rail must be resisted by the rail anchoring system. Between such locations, the forces in the rail are internally equalized, and the anchoring system will not be required to exert any restraining forces unless a rail failure or a sun kink occurs.

A sun kink is a lateral buckle of the track, which can occur in hot weather when the anchoring system and ballast in the roadbed do not provide adequate lateral restraint. Sun kinks are generally worse in tangent track than in curved track, since the track must buckle in a reverse curve in tangent alignment.

Often in the past, sun kinks would occur during the passage of a train and cause a derailment.

The railroad industry has researched the behavior of CWR in roadbed quite extensively over the years, and now experiences very few derailments due to sun kinks.

If the rail is allowed to creep longitudinally in the roadbed, higher stresses than predicted will occur. Therefore, it is important for the rail to maintain its location in the track.

And that's about all I know about CWR in roadbed.

Let's discuss CWR on bridges now.

CWR on Bridges

Twenty five years ago, when the use of CWR began to proliferate, most railroads were very cautious when using it near bridges. How the rail would perform was an unknown and there were few rules or guidelines governing its use on bridges.

The Chief Engineer of one railroad simplified the rules for welded rail on bridges for his company. He declared that CWR would not be placed on them.

Although this policy may have solved his anticipated problems with CWR, it created other problems. By making the rail discontinuous near the bridge ends, special attention had to be given to the anchoring system in those locations. In addition, this policy does not take advantage of the inherent benefits of CWR.

Today, when a CWR installation is done, it is generally placed continuously on all bridges within that relay length, also.

CWR installations on open deck bridges have experienced more problems than installations on ballasted deck bridges, apparently due to the anchoring systems used on open deck bridges.

Open deck bridges with bolted rail will generally experience damage to the ties under the rail joint because this is a weak spot in the rail. The higher impacts delivered to the rail joint are transmitted to the ties under the joint. Plate cut and splitting of the tie will occur at the joint first. After a joint tie has sustained damage, the adjacent ties begin to suffer, also.

As in roadbed, bad ties propagate bad ties.

Timber ties on open deck steel bridges are generally larger than track ties because they must perform more as a structural member than does a track tie. Bridge ties usually must be detailed and fabricated for a specific location. There are no standard bridge ties. Therefore, they are more expensive than track ties.

The installation of CWR on bridges greatly reduces the impacts that are delivered to the ties by the train wheels. CWR on bridges should promote longer tie life, if the installation is done properly. This longer tie life means savings for the owner.

But, what constitutes a proper installation of CWR on a bridge?

We might ask seven different railroad bridge engineers and get seven different answers. If we ask the roadmaster, we may get another opinion.

Chapter 15 of A.R.E.A. has recommendations for installing welded rail on bridges. Recommendations are made for open deck bridges and for ballasted deck. Short span installations and long spans are discussed. There are guidelines for tangent and curved track.

If A.R.E.A. has covered this topic so thoroughly, then why should there be any controversy? The controversial area is the treatment of CWR on long spans. What appears in the A.R.E.A. Manual for long spans is a field-tested installation procedure, that has worked well in many cases. But, at times, the prescribed procedures do not work right for a particular installation and other techniques have been utilized.

The reason that long spans can experience difficulties with CWR is that all railroad bridge spans change length with temperature and long spans move more than short ones.

If CWR is anchored continuously to a long steel span, the rail must either move with the span, and experience increased internal stresses, or the anchoring system must slip, or the bridge ties and tie spacers will split from the movement of the track.

We certainly don't want to increase the internal stresses in the rail and risk a track buckle just off the bridge.

And, on the other hand, if the rail anchoring system slips or damages the ties, we are using the wrong anchoring system.

So we conclude that the rail must be unanchored on long spans, or a special anchoring system must be employed.

Another solution is to introduce a rail expansion joint near the end of the span. This allows the rail to move with the span without inducing stresses in the rail. Rail expansion joints have worked well in many installations, and I would venture a guess that all major roads have one, or more, of these installations.

They are also used with all movable spans.

One method of anchoring rail on open deck bridges is to place rail anchors, such as Channellock or others, tightly on either side of all ties that are bolted to the span.

A fairly new anchoring system for bridges involves so-called elastic fasteners, as those developed by Pandrol. This system eliminates the need for conventional rail anchors. A steel clip provides the restraint to keep the rail from moving relative to the tie.

A variation on this system is the zero longitudinal restraint fastener. This fastener restrains the rail vertically and laterally, but allows the span to move longitudinally under the rail in response to temperature changes.

This system has been employed by several railroads recently with very favorable results. One road has used this system in order to eliminate rail expansion joints on one of their bridges.

This double track structure had six rail expansion joints which were removed when the new 136 lb rail and anchoring system were installed.

You may recall that earlier in this presentation, I suggested interviewing seven different railroad bridge engineers. Well, in fact, I did that several years ago, with the results shown in this table. You will notice that there is very little agreement between the various roads.

I would like now, to present a couple of case histories. This bridge has only one long span, but there are long approaches with numerous short spans.

The ties are moving and skewing, as though one rail is running north and the other one south.

Some of the ties have split.

Tie spacers have broken, as well.

This movement is occurring in spite of the fact that some of the ties are secured by an angle welded to the top flange of the span.

What is the solution? Perhaps a different rail anchoring system and continuous tie spacers would improve the situation.

In this case, approach embankment grades and direction of heavy traffic may be contributors to this phenomenon.

Another case history takes place near a small community that claims to be the home of Superman, Metropolis, Illinois.

A major bridge over the Ohio River had been experiencing movement in the CWR, in spite of having several rail expansion joints strategically placed.

This installation was with standard tie plates and spikes, and conventional rail anchors. This system was not able to restrain the rail from moving.

At one floorbeam, the ties had skewed and bunched badly.

At other locations, the ties were skewed and split.

The owner is presently experimenting with different anchoring systems and rail expansion joint configurations, and appears to be realizing some degree of success.

Conclusions and Recommendations

Ballasted deck bridges are usually less troublesome than open deck bridges with CWR.

Short spans and short bridges generally fare better than longer spans and bridges.

The rail anchoring system is very important. Rail expansion joints may be eliminated with the proper anchoring ystem.

Every bridge is unique.

Topics for Further Study

With the introduction of the new A/C traction locomotives, what will the effects of the increased traction forces be on CWR on open deck structures? Foutch and Tobias have done some work on this subject and reported their findings at the Workshop on Bridge Research in Progress, in July.

What contribution to resistance to seismic forces does CWR provide? The A.A.R. has conducted a full-size field test in California and has reported the results. In addition, the topic is currently an assignment for A.R.E.A.

Mr. Clark: Thank you, Ken. Our next feature is Amtrak's Track Alignment and will be presented by Paul Mertens, director of track geometry maintenance with Amtrak.

AMTRAK'S TRACK ALIGNMENT

Paul Mertens

Director of Track Geometry Maintenance
Amtrak

Surfacing by exception, the chosen method of track geometry maintenance on Amtrak's Northeast Corridor, is in its second year of utilization. It has taken almost 20 years to reach this point and will take a few more to achieve full impact.

Back in 1977 through 1980, the Northeast Corridor Improvement Project was in full swing with tie renewal, rail renewal, undercutting, concrete tie laying, switch renewal, et cetera. At this time, we had 45 tampers in our fleet for both construction and maintenance. Surfacing effectiveness was measured in feet. It didn't matter where we surfaced, only how much. Our surfacing program was to surface everything as often as we could.

We had a mixed fleet of tampers; therefore, there was no consistency. One could tell at 110 mph which machine or gang did the work. Surfacing switches was a long labor intensive effort with minimal quality.

1983 saw the first innovation, split head switch tamping by Jackson, which reduced labor required and improved quality.

In 1984, our first high capacity surfacing gang was assembled and put in service. It consisted of a 32-tool tamper and 16-tool tamper, 3 ballast regulators and 2 crib and shoulder compactors. It was a logistics nightmare. We were still doing block to block surfacing, but select blocks. The gang had a limited range.

1984 also saw the introduction of the dynamic track stabilizer with many unknowns to be proven. Many tests were performed. By this time, more detailed track geometry conditions reported by our geometry car became available.

In 1985, the track stabilizer replaced the crib and shoulder compactors and began full time utilization with more favorable slow release policy - 80 MPH on concrete ties for 25 hours and 60 MPH on wood ties.

1987 saw the start up of our 32-tool CAT MDZ. It could travel under signal indication at 50 MPH and had automatic geometry control. Production capacity was unheard of. Our production record was six miles in 7 1/2 hours production time. Normal production was four miles per night. Entering pre-calculated geometry information (spiral length, curve length, super elevation, et cetera) which was gathered by survey parties, into tamper, allowed geometry to be automatically controlled and did not rely on operator proficiency, thereby improving quality and consistency. This consist was tuned for production.

In 1988, our 16-tool CAT MDZ for wood ties arrives. We now had the capacity to surface New York to Washington all tracks in one season.

In 1989, our attention focussed on switches and interlockings with the arrival of our first Unimat 3S. Surveyed profiles deviated two inches to eleven inches. The 3S had the most flexible tamping head and three-point lifting. To achieve lifts we had to walk crossovers up. Ballast trains were a necessity each night. Too much ballast dropped ahead and only the rail comes up. We had to rely on local forces to drop and dress stone on switches. We estimated each switch had to be raised each year for three years until stable profile is achieved. A typical six crossover four track interlocking was taking three to four weeks to complete from home board to home board. Each year saw improvement.

The 1990 season saw our 16-tool CAT with automatic geometry guidance system addition being tested on the Springfield Line in Connecticut. It was quite an ordeal.

The automatic geometry guidance system opened up new avenues. Even though the system could mimic a smoothing pass, we wanted a full control application in both horizontal and vertical plane.

In 1991, our ballast management system arrived, doubled Unimat 3S production and provided quality dress using reclaimed ballast by sweeping up excess ballast and redistributing. This unit was now independent of work trains and division support.

Late 1991 saw our second Unimat 3S with automatic geometry guidance system. By coordinating track outages more precisely, our two Unimats were used side by side through a crossover lifting a 22-foot switch timber and tamping across its length simultaneously. Quality and obviously productivity improved. Bowed timbers were corrected. Profile was more uniformly achieved through an overlay program on the automatic geometry guidance system, whereby lifts on the long timber platform were matched track to track. By this time, an out-of-face surface and line job on a four track six crossover interlocking could be done in four nights. That is completely ballasted and dressed as well.

By the start of the 1992 season, all tampers, 32-tool CAT, 16-tool CAT and two Unimat 3S's had automatic geometry guidance system. A test of spot surfacing capability was conducted with the 16-tool MDZ. The average projection was four and a half spots or locations per night. The record achieved was spot tamping seven locations over a 128-mile range in one night with no slow order.

We knew as major track improvements were done, we had to hone our skills for this type of spot work. Geometry reports showed less block to block work and more isolated spots. This meant less wholesale out-of-face work. We had to develop new parameters for determining our surfacing needs.

1994 and 1995 saw the shift from wholesale out-of-face surfacing to surfacing by exception. We had limited capabilities since our equipment was either switch tampers or production tampers. This entailed a lot of moving around. In 1996, we took delivery of two 4S MDZ consists. The tamper is a 32-tool split head, tilt tool, continuous action switch tamper with improved three-point lift.

Instead of a ballast regulator, we a full ballast management system, and lastly, a standard off the shelf dynamic track stabilizer. All pieces couple together for 50 MPH travel under signal indication. Operators are qualified on our physical characteristics for travel. Through geometry car data and local inspectors, program priority each night is:

1. Existing slow order
2. Potential or borderline slow order
3. Construction support
4. Program block to block based on ride quality.

Geometry related slow orders not only affect on-time performance, but narrow or eliminate available windows or outages for scheduled track work. We know we cannot continue this forever. New studies have shown just how detrimental it is to continuously surface and tamp a rough area without applying a fix to the root cause. A plan is being developed and funded to engineer solutions to our historical rough areas and spots.

To summarize this evolution, we started with 26 surfacing gangs, 19 division maintenance, and 7 construction. We currently have 11 gangs, 4 division maintenance, 4 track geometry maintenance, and 3 construction. Eventually we intend to bring the number of gangs down to 6, 4 track geometry maintenance and 2 construction. This will effectively eliminate the local division surfacing gang. Division engineers' protests are diminishing once they realize the 4S consists are at their service to fulfill their surfacing requirements. The two remaining construction surfacing gangs will be track laying system and undercutter utilizing the 32 and 16-tool CAT tampers whose production capacity is more than adequate. The inclusion of dynamic track stabilizers with the CAT tampers provides the construction projects with a more stable and longer lasting product.

We will be monumenting the Northeast Corridor railroad starting in New England. This will be a horizontal, as well as vertical, monument. Maintenance practices will be developed to automatically surface and line track to these monuments.

In closing, we are now prepared to support the construction and maintenance of any track structure on the Northeast Corridor from 32.7 concrete "timber" switches to 150 MPH main line with quality and efficiency.

Mr. Clark: Thank you, Paul,

President Bradley: I'd like to thank everyone this morning for putting on the presentations. I'd also like to thank Joe Lileikis and Dwight Clark for effort they put forth in putting this program together.

At this time, I would like to call on the outgoing directors of the B&B Association, Mark Johnson and Dale Bartholomew. On behalf of the B&B Association, I would like to present plaques to Mark and Dave recognizing their participation and support over the past few years.

Mr. Johnson: Thank you.

Mr. Bartholomew: Thank you.

President Koff: At this time I would like to call the outgoing directors from the Roadmasters Association, Al Cloutier, Pete Murgas, and treasurer Darrell Cantrell, to come forward. On behalf of the Roadmasters Association I would like to thank them for their contribution during the past years. Director Reuven Shiloh has been reappointed to fill a one-year unexpired term.

President Bradley: At this time I'd like to call Joe Lileikis to read the Resolution Statement.

RESOLUTION STATEMENT

Mr. Lileikis: Having reached the closing of the Annual Joint Conference of the American Railway Bridge and Building Association and the Roadmasters and Maintenance of Way Association of America, and being deeply indebted to all those members and friends who have contributed their time and effort to make our conference a success, it is right that we should acknowledge this indebtedness and that it be so entered into the minutes of the meeting.

Be it further resolved that our deep appreciation be extended to those who have honored our Associations with their presence and by their informative addresses. Those include Timothy Dwyer, senior vice president - unit train operation, Conrail; Jake Jacobson, executive vice president, Copper Basin Railway; Jolene Molitoris, administrator, Federal Railroad Administration; Frank Martin, chief, permit section, U.S. Coast Guard; Roger Wiebusch, chief of bridge office, eighth district, U.S. Coast Guard, St. Louis; Norm Carlson, transportation director, Arthur Andersen; Dr. Gene Corley, vice president, Construction Technology Laboratories, Inc.; Tom Collier, Ercon Development Company; Karl Benzer, Utico Hard Rock Boring Company; Marv Keske, general roadmaster, BNSF; Mike Franke, vice president and chief engineer, BNSF; Michael Boyer, Applied Engineering and Sciences; Steve Hill, manager structures, CP Rail; Bill Komala, Ragnar Benson, Inc.; Cliff Shoemaker, director industrial and public projects, Union Pacific; Joe Hartmann, Hartmann Management Services; Dan Dalton, David L. Holt Company; Professor Bob Lohnes, Iowa State University; Theresa Galloway, director structures maintenance, CSX; Ken Bruestle, senior project manager, HNTB; Paul Mertens, director of track geometry maintenance, Amtrak; and Bob Kramer, REMSA, who did a fine job in bringing us up to date on innovations in the rail industry and to all the committee chairmen and sponsors who, with the loyal cooperation of the committee members, prepared the interesting and instructive reports that were presented.

Be it further resolved that a very special thanks is expressed to Bob Kramer, president of REMSA, and all members of the Railway Engineering Maintenance Suppliers Association for the fine reception and the hospitality we enjoyed during our conference.

Our thanks are also expressed to Mrs. Brenda Koff, Frances Dachs, and the committee members for their efforts in arranging registration and entertainment for our spouses.

A special thanks goes to Pat Weissmann and Barbara Marlow. Without their unselfish assistance, these two Associations would have great difficulty functioning.

Be it finally resolved that both Associations express their heartfelt thanks to our retiring presidents, Mike Bradley and Kendall Koff, who have spent so much time and effort into guiding the activities of our two Associations with great efficiency and dedication during the past year.

I move this resolution be adopted.

President Bradley: The following are the names of the officers-elect of the B&B Association for the year 1996-1997. Would the officers so named please step forward in front of the podium and take a position in front.

President Joe Lileikis, senior engineer structures, Amtrak.

Senior vice president, Bob Carter, manager public programs, BNSF.

Junior vice presidents, David Franz, bridge engineer, Kansas City Southern; and Jimmy Neece, supervisor facilities maintenance, CSX.

Treasurer, Don Lewis, assistant engineer structures, Illinois Central.

For directors with terms expiring in 1997: Pat Barrett, engineer construction and maintenance, BNSF; Dave Cook, superintendent B&B, Montana Rail Link; and Dick Dummar, manager architectural design, Union Pacific.

Directors with terms expiring in 1998: Richard Calhoun, associate, CTE; Willie Benton, engineer structures, Norfolk Southern; and Bill GeMeiner, manager methods and research, Union Pacific.

Directors with terms expiring in 1999: Steve Ross, steel structure inspector, Conrail; Gordon Davids, bridge engineer, FRA; and Preston Sargent, manager mechanical system designer, Union Pacific.

President Koff: The following have been chosen to serve as board of directors and officers for the 1996-1997 year:

President, Wayne Russell, AVP-line maintenance, BNSF.

First vice president Ron Poulsen, senior project manager, HDR.

Second vice president, Darrell Cantrell, engineer of track, BNSF.

Treasurer, Peter Murgas, manager re-engineering, Norfolk Southern.

Directors with terms expiring in 1997: Reuven Shiloh, assistant chief engineer - planning and support, Conrail; Bob Davis, production manager ties, Southern Pacific, and Dwight Clark, director quality manager - engineering, Union Pacific.

Directors with terms expiring in 1998: Bob King, supervisor engineering maintenance, CP Rail; Tom Long, manager engineering services, Indiana Harbor Belt; and Joe Riley, engineer standards, Metra.

Directors with terms expiring 1999: Dave Griffith, assistant division engineer, Norfolk Southern; Chris Dodge, chief engineer, RailTex; and Andy Sensing, engineering superintendent, Illinois Central.

Directors with terms expiring in 2000: Gordon Basra, supervisor track evaluation, CN; Bill Ross, track maintenance supervisor, CP Rail; and Bob Hunt, division engineer, Conrail.

President Bradley: As officers of the two Associations, you will represent to the general public the true meaning of railway bridge and building and roadway maintenance and construction. You will be our joint voice in the industry which will make you our common bond with railroad personnel everywhere.

President Koff: As officers in the two Associations, you will represent our best interests in any of our activities or projects, always reminding yourself that your attitude must be part in every undertaking sanctioned by your respective Associations. In this, you will be adhering strictly to the constitution and by-laws of our respective Associations.

As a representative of the Roadmasters Association, I install you in the office to which you have been elected.

President Bradley: As a representative of the Bridge and Building Association, I install each of you into office to which you have been elected.

Let's give these two boards a round of applause. (Applause)

Thank you. At this time, I would like to call on Bob Kramer, president of REMSA, to come to the podium.

Mr. Kramer: Text Unavailable.

President Lileikis: Thank you, Bob. It is my pleasure to present outgoing president, Mike Bradley, this plaque honoring his work this past year and also for the years he served as director and vice president.

Mr. Bradley: Thank you.

President Lileikis: I want to thank the Association members for their vote of confidence and support in allowing a person of my warped mentality to achieve the leadership position of this organization.

It's going to be one heck of a ride this next year with all of the challenges presented us.

I would be remiss if I didn't thank a few associates who have been instrumental in my activity: John Horney for getting me involved, Jim Beran and Stan McLaughlin for allowing me to continue, Don Lewis for bringing me onto the board some 100 years ago, and Mark Walbrun for recommending me for advancement into the executive board.

I would like to thank my wife for her continued support, but she has too good of a time attending these functions and I'd hardly consider my involvement a hardship.

The next year will be challenging with monthly merger association meetings, quarterly board meetings, and preparing for the 1997 Kansas City conferences. There will be monthly newsletters, which means I have to concoct creative words of wisdom, RT&S updates, bridge inspection seminars, and now the preparation of a manual of recommended practices for the inspection of railway bridges.

I am committed to this organization, yet somewhere in all of this, I have to find time for my regular (or irregular) duties at Amtrak.

I will now turn the podium over to Ken Koff.

Mr. Koff: Part of the tradition in Roadmasters is that we have a president's pin for the incoming president. It is my pleasure to present you with it.

President Russell: Thank you, Ken. Before I get into the Board's expectations for the upcoming year, I would like to take a few moments to review what I consider are major successes and initiations that Ken either introduced or gave major support to during his years on the Board.

They are:

- improved communications to the membership through a more comprehensive newsletter and monthly articles in RT&S.
- training seminars for individuals interested in track maintenance and inspection procedures.
- computerization of the annual proceedings to assist our membership research maintenance subjects without having to thumb through 10 to 15 annual proceedings manuals.
- the creation of strategic planning guidelines to keep the Board focussed on the emphasis of continual improvement of conference presentations through feedback from the members.
- interaction between our committee chairman and presentations specialists.

Ken has dedicated a tremendous amount of time and energy to improving this organization over the past ten years. We can all see the results of this efforts and leadership.

Ken, it is very difficult to properly reward individuals who have given as much as you have to the Roadmasters Association, but I know you enjoyed your presidency and your time

on the Board. On behalf of the membership and the Board, I would like for your wife, Brenda, to present you with the president's plaque.

Thank you, Brenda. Hopefully there will be more quality time for you and the children on the weekends now that this year is behind you. Maybe you'll get to spend a little more time on the beach. Thank you, again, Brenda and Ken.

I joined Roadmasters in 1979 and have spent the last six years on the Board of Directors.

This coming year promises to be an exciting one. The equipment show is planned for September 7 through 10 in Kansas City and we hope for a huge turnout there. It's also a challenging one in that we're working toward a combined conference in 1998 and the possibility of a combined organization of Roadmasters, B&B and AREA. With industry downsizing and less people and less time to do committee reports, presentations, and cover the myriad of duties, it seems to make sense to have one board govern either all three associations or a combined one.

I look forward to accepting the challenges before the Roadmasters Association today and in the coming year. I hope that all or at least many of you will lend your expertise to the reports to be presented during the 1997 conference.

The 1996 conference is now adjourned. See you in Kansas City.

(Meeting Adjourned)

1st Row: Bob Carter, Joe Lileikis, Mike Bradley, Pat Weissmann, Barbara Marlow
2nd Row: Dick Dummar, Pat Barrett, Willie Benton, Dave Franz, Bill GeMeiner,
Don Lewis, Dave Cook

Left to Right: Preston Sargent, Gordon Davids, Steve Ross, Bill GeMeiner, Rick Calhoun,
Dick Dummar, Pat Barrett, Don Lewis, Jimmy Neece, Joe Lileikis, Dave Cook

Past Officers

	1891–1892	1892–1893	1893–1894	1894–1895
President	O. J. Travis	H. M. Hall	J. E. Wallace	Geo. W. Andrews
1st V.-Pres.	H. M. Hall	J. E. Wallace	Geo. W. Andrews	W. A. McGonagle
2nd V.-Pres.	J. B. Mitchell	G. W. Hinman	W. A. McGonagle	L. K. Spafford
3rd V.-Pres.	James Stannard	N. W. Thompson	L. K. Spafford	James Stannard
4th V.-Pres.	G. W. Hinman	C. T. Fuller	E. D. Hines	Walter G. Berg
Secretary	C. W. Gooch	S. F. Patterson	S. F. Patterson	S. F. Patterson
Treasurer	George M. Reid	George M. Reid	George M. Reid	George M. Reid
Executive Members	W. R. Damon	G. W. Andrews	Q. McNab	James Stannard
	G. W. Markley	J. M. Staten	A. S. Markley	James H. Travis
	W. A. McGonagle	J. M. Caldwell	Floyd Ingram	J. H. Cummin
	C. W. McGehee	Q. McNab	James Stannard	R. M. Peck
	G. W. Turner	Floyd Ingram	James H. Travis	J. L. White
	J. E. Wallace	A. S. Markley	J. H. Cummin	A. Shane

	1895–1896	1896–1897	1897–1898	1898–1899
President	W. A. McGonagle	James Stannard	Walter G. Berg	J. M. Cummin
1st V.-Pres.	L. K. Spafford	Walter G. Berg	J. H. Cummin	A. S. Markley
2nd V.-Pres.	James Stannard	J. H. Cummin	A. S. Markley	C. C. Mallard
3rd V.-Pres.	Walter G. Berg	A. S. Markley	G. W. Hinman	W. A. Rogers
4th V.-Pres.	J. H. Cummin	R. M. Peck	C. C. Mallard	J. M. Staten
Secretary	S. F. Patterson	S. F. Patterson	S. F. Patterson	S. F. Patterson
Treasurer	George M. Reid	N. W. Thompson	N. W. Thompson	N. W. Thompson
Executive Members	R. M. Peck	W. O. Eggleston	G. J. Bishop	Wm. S. Danes
	L. J. White	W. M. Noon	C. P. Austin	J. H. Markley
	A. Shane	J. M. Staten	M. Riney	W. O. Eggleston
	A. S. Markley	G. J. Bishop	Wm. S. Danes	R. L. Heflin
	W. M. Noon	C. P. Austin	J. H. Markley	F. W. Tanner
	J. M. Staten	M. Riney	W. O. Eggleston	A. Zimmerman

	1899–1900	1900–1901	1901–1902	1902–1903
President	Aaron S. Markley	W. A. Rogers	W. S. Danes	B. F. Pickering
1st V.-Pres.	W. A. Rogers	W. S. Danes	B. F. Pickering	C. C. Mallard
2nd V.-Pres.	J. M. Staten	B. G. Pickering	A. Shane	A. Shane
3rd V.-Pres.	Wm. S. Danes	A. Shane	A. Zimmerman	A. Zimmerman
4th V.-Pres.	B. F. Pickering	A. Zimmerman	C. C. Mallard	A. Montzheimer
Secretary	S. F. Patterson	S. F. Patterson	S. F. Patterson	S. F. Patterson
Treasurer	N. W. Thompson	N. W. Thompson	N. W. Thompson	N. W. Thompson
Executive Members	T. M. Strain	T. M. Strain	A. Montzheimer	W. E. Smith
	R. L. Heflin	H. D. Cleaveland	W. E. Smith	A. W. Merrick
	F. W. Tanner	F. W. Tanner	A. W. Merrick	C. P. Austin
	A. Zimmerman	A. Montzheimer	C. P. Austin	C. A. Lichty
	H. D. Cleaveland	W. E. Smith	C. A. Lichty	W. O. Eggleston
	A. Montzheimer	A. W. Merrick	W. O. Eggleston	J. H. Markley

	1903–1904	1904–1905	1905–1906	1906–1907
President	A. Montzheimer	C. A. Lichty	J. B. Sheldon	J. H. Markley
1st V.-Pres.	A. Shane	J. B. Sheldon	J. H. Markley	R. H. Reid
2nd V.-Pres.	C. A. Lichty	J. H. Markley	R. H. Reid	J. P. Canty
3rd V.-Pres.	J. B. Sheldon	R. H. Reid	R. C. Sattley	H. Rettinghouse
4th V.-Pres.	J. H. Markley	R. C. Sattley	J. P. Canty	F. E. Schall
Secretary	S. F. Patterson	S. F. Patterson	S. F. Patterson	S. F. Patterson
Treasurer	C. P. Austin	C. P. Austin	C. P. Austin	C. P. Austin
Executive Members	R. H. Reid	W. O. Eggleston	H. Rettinghouse	W. O. Eggleston
	W. O. Eggleston	A. E. Killam	A. E. Killam	A. E. Killam
	A. E. Killam	H. Rettinghouse	J. S. Lemond	J. S. Lemond
	R. C. Sattley	J. S. Lemond	C. W. Richey	C. W. Richey
	H. Rettinghouse	W. H. Finley	W. O. Eggleston	H. H. Eggleston
	J. S. Lemond	C. W. Richey	F. E. Schall	B. J. Sweatt

	1907–1908	1908–1909	1909–1910	1910–1911
President	R. H. Reid	J. P. Canty	H. Rettinghouse	H. Rettinghouse
1st V.-Pres.	J. P. Canty	H. Rettinghouse	J. S. Lemond	F. E. Schall
2nd V.-Pres.	H. Rettinghouse	F. E. Schall	F. E. Schall	A. E. Killam
3rd V.-Pres.	F. E. Schall	J. S. Lemond	A. E. Killam	J. N. Penwell
4th V.-Pres.	W. O. Eggleston	A. E. Killam	J. N. Penwell	L. D. Hadwen
Secretary	S. F. Patterson	S. F. Patterson	C. A. Lichty	C. A. Lichty
Treasurer	C. P. Austin	C. P. Austin	J. P. Canty	J. P. Canty
Executive Members	A. E. Killam	J. N. Penwell	W. Beahan	T. J. Fullem
	J. S. Lemond	Willard Beahan	F. B. Scheetz	G. Aldrich
	C. W. Richey	F. B. Scheetz	L. D. Hadwen	P. Swenson
	T. S. Leake	W. H. Finley	T. J. Fullem	G. W. Rear
	W. H. Finley	L. D. Hadwen	G. Aldrich	W. O. Eggleston
	J. N. Penwell	T. J. Fullem	P. Swenson	W. F. Steffens

	1911–1912	1912–1913	1913–1914	1914–1915
President	F. E. Schall	A. E. Killam	J. N. Penwell	L. D. Hadwen
1st V.-Pres.	A. E. Killam	J. N. Penwell	L. D. Hadwen	G. Aldrich
2nd V.-Pres.	J. N. Penwell	L. D. Hadwen	G. Aldrich	G. W. Rear
3rd V.-Pres.	L. D. Hadwen	T. J. Fullem	G. W. Rear	C. E. Smith
4th V.-Pres.	T. J. Fullen	G. Aldrich	C. E. Smith	E. B. Ashby
Secretary	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Treasurer	J. P. Canty	J. P. Canty	J. P. Canty	F. E. Weise
Executive Members	G. Aldrich	G. W. Rear	W. F. Steffens	W. F. Steffens
	P. Swenson	W. F. Steffens	E. B. Ashby	S. C. Tanner
	G. W. Rear	E. B. Ashby	S. C. Tanner	Lee Jutton
	W. F. Steffens	C. E. Smith	Lee Jutton	F. F. Strouse
	E. B. Ashby	S. C. Tanner	W. F. Strouse	C. R. Knowles
	W. O. Eggleston	Lee Jutton	C. R. Knowles	A. Ridgway

	1915–1916	1916–1917	1917–1918	1918–1919
President	G. W. Rear	C. E. Smith	S. C. Tanner	Lee Jutton
1st V.-Pres.	C. E. Smith	E. B. Ashby	Lee Jutton	F. E. Weise
2nd V.-Pres.	E. B. Ashby	S. C. Tanner	F. E. Weise	W. F. Strouse
3rd V.-Pres.	S. C. Tanner	Lee Jutton	W. F. Strouse	C. R. Knowles
4th V.-Pres.	Lee Jutton	F. E. Weise	C. R. Knowles	A. Ridgway
Sec.-Treas.	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Executive Members	F. E. Weise	W. F. Strouse	A. Ridgway	J. S. Robinson
	W. F. Strouse	C. R. Knowles	J. S. Robinson	J. P. Wood
	C. R. Knowles	A. Ridgway	J. P. Wood	A. B. McVay
	A. Ridgway	J. S. Robinson	D. C. Zook	J. H. Johnston
	J. S. Robinson	J. P. Wood	A. B. McVay	E. T. Howson
	J. P. Wood	D. C. Zook	J. H. Johnston	C. W. Wright

	1919–1920	1920–1921	1921–1922	1922–1923
President	F. E. Weise	W. F. Strouse	C. R. Knowles	Arthur Ridgway
1st V.-Pres.	W. F. Strouse	C. R. Knowles	A. Ridgway	J. P. Wood
2nd V.-Pres.	C. R. Knowles	A. Ridgway	J. S. Robinson	J. S. Robinson
3rd V.-Pres.	A. Ridgway	J. S. Robinson	J. P. Wood	C. W. Wright
4th V.-Pres.	J. S. Robinson	J. P. Wood	C. W. Wright	E. T. Howson
Sec.-Treas.	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Asst. Sec.			F. E. Weise	F. E. Weise
Directors	J. P. Wood	C. W. Wright	E. T. Howson	F. C. Baluss
	A. B. McVay	A. B. McVay	J. H. Johnson	Maro Johnson
	J. H. Johnston	G. A. Manthey	E. K. Barrett	O. F. Dalstrom
	E. T. Howson	E. T. Howson	F. C. Baluss	S. D. Corey
	C. W. Wright	J. H. Johnston	Maro Johnson	W. B. Hotson
	G. A. Manthey	E. K. Barrett	O. F. Dalstrom	P. N. Nelson

	1923–1924	1924–1925	1925–1926	1926–1927
President	J. S. Robinson	J. P. Wood	C. W. Wright	E. T. Howson
1st V.-Pres.	J. P. Wood	C. W. Wright	E. T. Howson	F. C. Baluss
2nd V.-Pres.	C. W. Wright	E. T. Howson	F. C. Baluss	Maro Johnson
3rd V.-Pres.	E. T. Howson	F. C. Baluss	Maro Johnson	J. S. Huntoon
4th V.-Pres.	F. C. Baluss	Maro Johnson	J. S. Huntoon	C. S. Heritage
Sec.-Treas.	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Asst. Sec.	F. E. Weise	F. E. Weise	F. E. Weise	F. E. Weise
Directors	S. T. Corey	J. S. Huntoon	C. S. Heritage	A. I. Gauthier
	W. B. Hotson	A. I. Gauthier	W. B. Hotson	E. L. Sinclair
	P. N. Nelson	E. L. Sinclair	P. N. Nelson	P. F. Dalstrom
	J. S. Huntoon	C. S. Heritage	A. I. Gauthier	W. T. Krausch
	A. I. Gauthier	W. B. Hotson	E. L. Sinclair	R. C. Bardwell
	E. L. Sinclair	P. N. Nelson	O. F. Dalstrom	H. I. Benjamin

	1927–1928	1928–1929	1929–1930	1930–1934
President	F. C. Baluss	Maro Johnson	J. S. Huntoon	C. S. Heritage
1st V.-Pres.	Maro Johnson	J. S. Huntoon	C. S. Heritage	A. I. Gauthier
2nd V.-Pres.	J. S. Huntoon	C. S. Heritage	A. I. Gauthier	H. I. Benjamin
3rd V.-Pres.	C. S. Heritage	A. I. Gauthier	H. I. Benjamin	W. T. Krausch
4th V.-Pres.	A. I. Gauthier	H. I. Benjamin	W. T. Krausch	T. H. Strate
Sec.-Treas.	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Asst. Sec.	F. E. Weise	F. E. Weise		
Directors	W. T. Krausch	R. C. Henderson	G. A. Rodman	E. C. Neville
	R. C. Bardwell	J. S. Ekey	W. A. Batey	H. H. Best
	H. I. Benjamin	T. H. Strate	F. W. Hillman	J. E. King
	R. C. Henderson	G. A. Rodman	E. C. Neville	A. B. Scowden
	T. H. Strate	W. A. Batey	H. H. Best	W. A. Batey
	J. S. Ekey	F. W. Hillman	J. E. King	L. C. Smith

	1934–1935	1935–1936	1936–1937	1937–1938
President	H. I. Benjamin	T. H. Strate	E. C. Neville	C. M. Burpee
1st V.-Pres.	T. H. Strate	E. C. Neville	C. M. Burpee	F. H. Masters
2nd V.-Pres.	E. C. Neville	C. M. Burpee	F. H. Masters	W. S. Lacher
3rd V.-Pres.	A. B. Scowden	F. H. Masters	C. A. J. Richards	C. A. J. Richards
4th V.-Pres.	W. R. Roof	C. A. J. Richards	W. S. Lacher	F. H. Cramer
Sec.-Treas.	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Directors	C. M. Burpee	A. L. McCloy	W. R. Roof	B. R. Meyers
	W. A. Batey	R. P. Luck	T. P. Soule	G. S. Crites
	L. C. Smith	H. H. Best	F. H. Cramer	R. E. Dove
	C. A. J. Richards	W. R. Roof	B. R. Meyers	T. P. Soule
	A. L. McCloy	T. P. Soule	G. S. Crites	A. Chinn
	R. P. Luck	F. H. Cramer	R. E. Dove	L. G. Byrd

	1938–1939	1939–1940	1940–1941	1941–1942
President	Armstrong Chinn	A. E. Bechtelheimer	H. M. Church	R. E. Dove
1st V.-Pres.	F. H. Cramer	F. H. Cramer	R. E. Dove	F. H. Soothill
2nd V.-Pres.	A. E. Bechtelheimer	H. M. Church	F. A. Soothill	G. S. Crites
3rd V.-Pres.	H. M. Church	R. E. Dove	G. S. Crites	A. M. Knowles
4th V.-Pres.	R. E. Dove	F. H. Soothill	A. M. Knowles	N. D. Howard
Sec.-Treas.	C. A. Lichty	C. A. Lichty		
Secretary	. . . . .	. . . . .	F. O. Whiteman	A. G. Shaver
Treasurer	. . . . .	. . . . .	F. E. Weise	F. E. Weise
Directors	L. G. Byrd	B. R. Meyers	N. D. Howard	R. E. Caudle
	W. R. Ganser	W. Walkden	L. G. Byrd	I. A. Moore
	F. H. Soothill	A. S. Krefting	K. L. Miner	W. A. Sweet
	B. R. Meyers	A. M. Knowles	R. E. Caudle	J. L. Varker
	W. Walkden	L. G. Byrd	I. A. Moore	L. E. Peyser
	A. S. Krefting	K. L. Miner	W. A. Sweet	Martin Meyer

	1942–1943	1943–1944	1944–1945	1945–1946
President	G. S. Crites	J. L. Varker	J. L. Varker	N. D. Howard
1st V.-Pres.	R. E. Caudle	R. E. Caudle	R. E. Caudle	F. G. Campbell
2nd V.-Pres.	A. M. Knowles	N. D. Howard	N. D. Howard	J. S. Hancock
3rd V.-Pres.	N. D. Howard	F. G. Campbell	F. G. Campbell	E. H. Barnhart
4th V.-Pres.	J. L. Varker	J. S. Hancock	J. S. Hancock	W. F. Martens
Secretary	A. G. Shaver†	Elinor V. Heffern	Elise LaChance	Elise LaChance
	Lorene Kindred‡			
	Elinor V. Heffern			
Treasurer	F. E. Weise	C. R. Knowles	C. R. Knowles	C. R. Knowles
Treasurer Emeritus		F. E. Weise	F. E. Weise	
Directors	M. Meyer	W. F. Martens	W. F. Martens	A. B. Chapman
	L. E. Peyser	A. L. McCloy	A. L. McCloy	W. A. Huckstep
	K. L. Miner	L. C. Winkelhaus	L. C. Winkelhaus	F. R. Spofford
	F. G. Campbell	E. H. Barnhart	E. H. Barnhart	Guy E. Martin
	J. S. Hancock	A. B. Chapman	A. B. Chapman	B. R. Meyers
	L. C. Winkelhaus	L. E. Peyser	L. E. Peyser	L. E. Peyser

† To November 1, 1942 ‡ To February 1, 1943

	1946–1947	1947–1948	1948–1949	1949–1950
President	F. G. Campbell	J. S. Hancock	E. H. Barnhart	W. F. Martens
1st V.-Pres.	J. S. Hancock	E. H. Barnhart	W. F. Martens	W. A. Huckstep
2nd V.-Pres.	E. H. Barnhart	W. F. Martens	W. A. Huckstep	Guy E. Martin
3rd V.-Pres.	W. F. Martens	W. A. Huckstep	Guy E. Martin	F. R. Spofford
4th V.-Pres.	W. A. Huckstep	G. E. Martin	F. R. Spofford	Lee Mayfield
Secretary	Elise LaChance	Elise LaChance	Elise LaChance	Elise LaChance
Treasurer	C. R. Knowles	C. R. Knowles	L. C. Winkelhaus	L. C. Winkelhaus
Directors	Guy E. Martin	H. M. Harlow	Lee Mayfield	H. M. Harlow
	B. R. Meyers	H. B. Christianson	F. M. Misch	V. E. Engman
	L. E. Peyser	F. R. Spofford	W. D. Gibson	G. W. Benson
	H. M. Harlow	Lee Mayfield	H. M. Harlow	F. M. Misch
	H. B. Christianson	Franz M. Misch	V. E. Engman	L. R. Morgan
	F. R. Spofford	W. D. Gibson	G. W. Benson	J. A. Jorlett

	1950–1951	1951–1952	1952–1953	1953–1954
President	W. A. Huckstep	Guy E. Martin	F. R. Spofford	Lee Mayfield
1st V.-Pres.	Guy E. Martin	F. R. Spofford	Lee Mayfield	H. M. Harlow
2nd V.-Pres.	F. R. Spofford	Lee Mayfield	H. M. Harlow	J. A. Jorlett
3rd V.-Pres.	Lee Mayfield	H. M. Harlow	J. A. Jorlett	R. R. Gunderson
4th V.-Pres.	H. M. Harlow	J. A. Jorlett	R. R. Gunderson	W. H. Huffman
Secretary	Elise LaChance	Elise LaChance	Elise LaChance	Elise LaChance
Treasurer	L. C. Winkelhaus	L. C. Winkelhaus	L. C. Winkelhaus	L. C. Winkelhaus
Directors	F. M. Misch	M. H. Dick	W. H. Huffman	M. H. Dick
	L. R. Morgan	R. R. Gunderson	L. R. Morgan	J. F. Warrenfells
	J. A. Jorlett	J. F. Warrenfells	B. M. Stephens	G. Switzer
	M. H. Dick	W. H. Huffman	M. H. Dick	B. M. Stephens
	R. R. Gunderson	L. R. Morgan	J. F. Warrenfells	W. H. Bunge
	J. F. Warrenfells	B. M. Stephens	G. Switzer	E. R. Schlaf

	1954–1955	1955–1956	1956–1957	1957–1958
President	H. M. Harlow	J. A. Jorlett	R. R. Gunderson	W. H. Huffman
1st V.-Pres.	J. A. Jorlett	R. R. Gunderson	W. H. Huffman	M. H. Dick
2nd V.-Pres.	R. R. Gunderson	W. H. Huffman	M. H. Dick	B. M. Stephens
3rd V.-Pres.	W. H. Huffman	M. H. Dick	B. M. Stephens	H. D. Curie
4th V.-Pres.	M. H. Dick	B. M. Stephens	H. D. Curie	
Secretary	Elise LaChance	Elise LaChance	Elise LaChance	Elise LaChance
Treasurer	L. C. Winkelhaus	L. C. Winkelhaus	L. C. Winkelhaus	L. C. Winkelhaus
Directors	B. M. Stephens	J. F. Warrenfells	W. H. Bunge	G. W. Benson
	W. H. Bunge	H. D. Curie	E. R. Schlaf	J. M. Lowry
	E. R. Schlaf	J. M. Lowry	G. W. Benson	H. H. Matthews
	J. F. Warrenfells	W. H. Bunge	J. M. Lowry	T. M. VonSprecken
	H. D. Curie	E. R. Schlaf	T. M. VonSprecken	W. H. Bunge
	J. M. Lowry	G. W. Benson	H. A. Matthews	E. R. Schlaf

	1958–1959	1959–1960	1960–1961	1961–1962
President	M. H. Dick	B. M. Stephens	H. D. Curie	G. W. Benson
1st V.-Pres.	B. M. Stephens	H. D. Curie	G. W. Benson	J. M. Lowry
2nd V.-Pres.	H. D. Curie	G. W. Benson	J. M. Lowry	E. R. Schlaf
3rd V.-Pres.	G. W. Benson	J. M. Lowry	E. R. Schlaf	H. A. Matthews
Secretary	Ruth Weggeberg	Ruth Weggeberg	Ruth Weggeberg	Ruth Weggeberg
Treasurer	L. C. Winkelhaus	L. C. Winkelhaus	L. C. Winkelhaus	L. C. Winkelhaus
Directors	J. M. Lowry	W. H. Bunge	H. A. Matthews	R. C. Baker
	R. C. Baker	E. R. Schlaf	M. J. Hubbard	R. H. Miller
	W. H. Bunge	H. A. Matthews	R. C. Baker	Shirley White
	E. R. Schlaf	M. J. Hubbard	R. H. Miller	H. M. Wilson
	H. A. Matthews	R. C. Baker	Shirley White	R. D. Hellweg
	M. J. Hubbard	R. H. Miller	H. M. Wilson	F. W. Hutcheson

	1962–1963	1963–1964	1964–1965	1965–1966
President	J. M. Lowry	E. R. Schlaf	R. C. Baker	H. M. Wilson
1st V.-Pres.	E. R. Schlaf	R. C. Baker	H. M. Wilson	R. D. Hellweg
2nd V.-Pres.	H. A. Matthews	Shirley White	R. D. Hellweg	J. W. DeValle
3rd V.-Pres.	R. C. Baker	H. M. Wilson	J. W. DeValle	W. F. Armstrong
Secretary	Ruth Weggeberg	Ruth Weggeberg	Ruth Weggeberg	Ruth Weggeberg
Treasurer	L. C. Winkelhaus	E. F. Snyder	E. F. Snyder	E. F. Snyder
Directors	Shirley White	R. D. Hellweg	W. F. Armstrong	J. A. Goforth
	H. M. Wilson	F. W. Hutcheson	J. S. Ellis	E. R. Simmons
	R. D. Hellweg	W. F. Armstrong	J. A. Goforth	N. D. Bryant
	F. W. Hutcheson	J. W. DeValle	E. R. Simmons	A. R. Dahlberg
	W. F. Armstrong	J. A. Goforth	N. D. Bryant	J. S. Ellis
	J. W. DeValle	E. R. Simmons	A. R. Dahlberg	T. L. Fuller

	1966–1967	1967–1968	1968–1969	1969–1970
President	R. D. Hellweg	J. W. DeValle	W. F. Armstrong	J. A. Goforth
1st V.-Pres.	J. W. DeValle	W. F. Armstrong	J. A. Goforth	A. R. Dahlberg
2nd V.-Pres.	W. F. Armstrong	J. A. Goforth	A. R. Dahlberg	T. L. Fuller
3rd V.-Pres.	J. A. Goforth	A. R. Dahlberg	T. L. Fuller	N. D. Bryant
Secretary	Ruth Weggeberg	Ruth Weggeberg	Ruth Weggeberg	Ruth Weggeberg
Treasurer	W. H. Huffman	W. H. Huffman	W. H. Huffman	W. H. Huffman
Directors	N. D. Bryant	J. S. Ellis	N. F. Lucas	W. H. Rankin
	A. R. Dahlberg	T. L. Fuller	W. L. Short	E. E. Runde
	H. F. Lucas	R. A. Youngblood	C. E. Wachter	T. A. Reynolds
	J. S. Ellis	H. F. Lucas	A. C. Jones	J. J. Ridgeway
	T. L. Fuller	W. L. Short	W. H. Rankin	J. R. Williams
	R. A. Youngblood	C. E. Wachter	E. E. Runde	J. W. Chambers
	V. D. Raessler	A. C. Jones	T. A. Reynolds	R. E. Frame
	W. L. Short	W. H. Rankin	J. J. Ridgeway	J. C. Hobbs
	C. E. Wachter	E. E. Runde	J. R. Williams	

	1970–1971	1971–1972	1972–1973	1973–1974
President	A. R. Dahlberg	T. L. Fuller	N. D. Bryant	E. E. Runde
1st V.-Pres.	T. L. Fuller	N. D. Bryant	E. E. Runde	J. J. Ridgeway
2nd V.-Pres.	N. D. Bryant	E. E. Runde	J. J. Ridgeway	J. R. Williams
3rd V.-Pres.	E. E. Runde	J. J. Ridgeway	J. R. Williams	W. R. Rankin
Secretary	Ann Wilson	Ann Wilson	Ann Wilson	Ann Wilson
Treasurer	W. H. Huffman	W. H. Huffman	W. H. Huffman	W. H. Huffman
Directors	T. A. Reynolds	J. W. Chambers	R. K. Corbett	D. C. Gould
	J. J. Ridgeway	R. E. Frame	J. R. Iwinski	W. S. Stokely
	J. R. Williams	J. C. Hobbs	J. S. Pritchett	W. C. Sturm
	J. W. Chambers	R. K. Corbett	D. C. Gould	J. W. Davidson
	R. E. Frame	J. R. Iwinski	W. S. Stokely	C. A. Hughes
	J. C. Hobbs	J. S. Pritchett	W. C. Sturm	W. R. Hyma
	R. K. Corbett	D. C. Gould	J. W. Davidson	O. C. Denz
	J. R. Iwinsky	W. S. Stokely	C. A. Hughes	R. C. McMaster
	J. S. Pritchett	W. C. Sturm	W. R. Hyma	W. E. Brakensiek

PAST OFFICERS

	1974-1975	1975-1976	1976-1977	1977-1978
President	J. J. Ridgeway	J. R. Williams	W. H. Rankin	J. R. Iwinski
1st V.-Pres.	J. R. Williams	W. H. Rankin	J. R. Iwinski	W. C. Sturm
2nd V.-Pres.	W. H. Rankin	J. C. Hobbs	W. C. Sturm	D. C. Gould
3rd V.-Pres.	J. C. Hobbs	J. R. Iwinski	D. C. Gould	J. W. Chambers
Secretary	Ann Wilson	Ann Wilson	Ann Wilson	Ann Wilson
Treasurer	W. H. Huffman	W. H. Huffman	W. H. Huffman	W. H. Huffman
Directors	J. W. Davidson	W. E. Brakensiek	J. W. Chambers	W. J. Gunkle
	C. A. Hughes	O. C. Denz	M. Noyszewski	W. E. Halley
	W. R. Hyma	R. C. McMaster	W. J. Gunkle	K. L. Wammell
	W. E. Brakensiek	F. R. Lindsay	W. E. Halley	J. Budzileni
	O. C. Denz	M. Noyszewski	K. L. Wammel	B. J. King
	R. C. McMaster	W. C. Sturm	J. Budzileni	J. G. Robertson
	F. B. Lindsay, Jr.	W. J. Gunkle	B. J. King	O. C. Denz
	M. Noyszewski	W. E. Halley	J. G. Robertson	E. C. Patterson
	Jim Payne	K. L. Wammel		W. S. Stokely

	1978-1979	1979-1980	1980-1981	1981-1982
President	W. C. Sturm	D. C. Gould	J. W. Chambers	W. R. Hyma
Sr. V.-Pres.	D. C. Gould	J. W. Chambers	R. C. McMaster	O. C. Denz
Jr. V.-Pres.	J. W. Chambers	R. C. McMaster	W. R. Hyma	J. Budzileni
Jr. V.-Pres.	R. C. McMaster	W. R. Hyma	O. C. Denz	J. M. Williams
Secretary	Ann Wilson	Ann Wilson	Ann Wilson	Pat Weissmann
Treasurer	W. F. Armstrong	W. F. Armstrong	W. F. Armstrong	W. C. Sturm
Directors	J. Budzileni	O. C. Denz	J. W. Davidson	D. A. Bessey
	B. J. King	W. J. Gunkle	C. M. Russell	J. N. Michel
	J. G. Robertson	W. S. Stokely	J. M. Williams	P. H. Saletnik
	O. C. Denz	L. D. Green	D. A. Bessey	O. D. Anthony
	E. C. Patterson	C. M. Russell	J. N. Michel	J. T. Kapp
	W. S. Stokely	J. M. Williams	P. H. Saletnik	D. J. Lewis
	L. D. Green	D. A. Bessey	O. D. Anthony	J. W. Davidson
	C. M. Russell	J. N. Michel	J. T. Kapp	H. J. Laga
	J. M. Williams	P. H. Saletnik	D. J. Lewis	A. S. Uppal

	1982-1983	1983-1984	1984-1985	1985-1986
President	O. C. Denz	J. Budzileni	J.M. Williams	D. A. Bessey
Sr. Vice President	J. Budzileni	J.M. Williams	D.A. Bessey	J. T. Kapp
Jr. Vice President	J. M. Williams	D.A. Bessey	J.T. Kapp	D. J. Lewis
Jr. Vice President	D. A. Bessey	J.T. Kapp	D.J. Lewis	R. A. Tallent
Secretary	P. A. Weissmann	P.A. Weissmann	P.A. Weissmann	P. A. Weissmann
Treasurer	P. H. Saletnik	P.H. Saletnik	P.H. Saletnik	J. M. Williams
Directors	O. D. Anthony	J.W. Davidson	T.E. Kuhn	B. T. Burns
	J. T. Kapp	D.J. Lewis	D.R. Ladner	J. J. Horney
	D. J. Lewis	T.E. Kuhn	R.A. Tallent	W. J. Semioli
	J. W. Davidson	D.R. Ladner	B.T. Burns	R. E. Fronczak
	H. J. Laga	R.A. Tallent	J.J. Horney	W. P. Cunningham
	A. S. Uppal	B.T. Burns	W.J. Semioli	J. H. Smith
	T. E. Kuhn	J.J. Horney	D.W. Brookings	E. Bond
	D. R. Ladner	W.J. Semioli	W.P. Cunningham	D. L. Steele
	R. A. Tallent		J.H. Smith	M. C. Walbrun

	1986-1987	1987-1988	1988-1989	1989-1990
President	J. T. Kapp	D. J. Lewis	R. A. Tallent	B. T. Burns
Sr. Vice President	D. J. Lewis	R. A. Tallent	B. T. Burns	J. J. Horney
Jr. Vice President	R. A. Tallent	B. T. Burns	J. J. Horney	M. C. Walbrun
Jr. Vice President	B. T. Burns	J. J. Horney	M. C. Walbrun	P. H. Saletnik
Secretary	P. A. Weissmann	P. A. Weissmann	P. A. Weissmann	P. A. Weissmann
Treasurer	J. M. Williams	J. M. Williams	J. M. Williams	J. M. Williams
Directors	W. H. Nelson	M. C. Walbrun	C. E. Thompson	W. H. Nelson
	J. H. Smith	S. Lipkus	H. L. Davidson	T. J. Parker
	J. J. Horney	D. L. Steele	J. A. VanHuis	R. C. Karsten
	M. C. Walbrun	C. E. Thompson	W. H. Nelson	R. C. Carter
	E. Bond	H. L. Davidson	T. J. Parker	T. V. Dunn
	D. L. Steele	J. A. VanHuis	R. C. Karsten	M. L. Bradley
	C. E. Thompson	W. H. Nelson	S. Lipkus	D. G. DeBerg
	H. L. Davidson	T. J. Parker	T. V. Dunn	D. F. Sorgenfrei
	J. A. VanHuis	R. C. Karsten	M. L. Bradley	J. A. Lileikis

	1990-1991	1991-1992	1992-1993	1993-1994
President	J. J. Horney	M. C. Walbrun	P. H. Saletnik	D. L. Steele
Sr. Vice President	M. C. Walbrun	P. H. Saletnik	D. L. Steele	J. A. Van Huis
Jr. Vice President	P. H. Saletnik	D. L. Steele	J. A. Van Huis	M. L. Bradley
Jr. Vice President	W. H. Nelson	J. A. Van Huis	M. L. Bradley	J. A. Lileikis
Secretary	P. A. Weissmann	P. A. Weissmann	P. A. Weissmann	P. A. Weissmann
Treasurer	J. M. Williams	D. J. Lewis	D. J. Lewis	D. J. Lewis
Directors	R. C. Carter	D. G. DeBerg	D. L. McCammon	R. W. Carter
	T. V. Dunn	D. F. Sorgenfrei	J. T. Creighton	C. W. Young
	M. L. Bradley	J. A. Lileikis	J. G. Bradley	D. K. Franz
	D. G. DeBerg	D. L. McCammon	R. W. Carter	J. L. Hostler
	D. F. Sorgenfrei	J. T. Creighton	C. W. Young	J. L. Neece
	J. A. Lileikis	J. G. Bradley	D. K. Franz	R. W. Kaye
	D. L. McCammon	R. W. Carter	J. L. Hostler	M. L. Johnson
	J. T. Creighton	C. W. Young	J. L. Neece	T. Rich
	J. G. Bradley	D. K. Franz	R. W. Kaye	D. E. Bartholomew

PAST OFFICERS

	1994-1995	1995-1996	1996-1997
President	J. A. Van Huis	M. L. Bradley	J. A. Lileikis
Sr. Vice President	M. L. Bradley	J. A. Lileikis	R. W. Carter
Jr. Vice President	J. A. Lileikis	R. W. Carter	D. K. Franz
Jr. Vice President	R. W. Carter	D. K. Franz	J. L. Neece
Administrative Director	P. A. Weissmann	P. A. Weissmann	P. A. Weissmann
Treasurer	D. J. Lewis	D. J. Lewis	D. J. Lewis
Directors	J. L. Hostler	M. L. Johnson	P. L. Barrett
	J. L. Neece	T. Rich	D. W. Cook
	R. W. Kaye	D. E. Bartholomew	R. C. Dummar
	M. L. Johnson	P. L. Barrett	R. L. Calhoun
	T. Rich	D. W. Cook	W. Benton III
	D. E. Bartholomew	R. C. Dummar	W. G. GeMeiner
	P. L. Barrett	R. L. Calhoun	R. S. Ross
	D. W. Cook	W. Benton III	G. A. Davids
	R. C. Dummar	W. G. GeMeiner	P. E. Sargent

CONSTITUTION

(Revised September 18, 1990)

ARTICLE I

NAME

Section 1. This Association shall be known as the American Railway Bridge and Building Association.

ARTICLE II

OBJECT

Section 1. The object of this Association shall be the advancement of knowledge pertaining to the design, construction and maintenance of railway structures and fixed facilities by investigation, reports and discussions.

Section 2. The Association shall neither endorse nor recommend any particular devices, trademarks or materials, nor will it be responsible for any opinions expressed in papers, reports or discussion unless the same have received the endorsement of the Association in regular session.

ARTICLE III

MEMBERSHIP

Section 1. The membership of this Association shall be divided into five classes: Members, Life members, Associate members, Honorary members and Junior members.

Section 2. A member shall be a person in the railway industry (except representatives of manufacturers and/or suppliers of equipment, material or labor services) engaged in engineering, construction and maintenance of railway structures and fixed facilities; a person in the employ of a public regulatory body; a professor of engineering or architecture; a technical editor; a materials expert; a consulting engineer, or an engineer employed by a consulting engineering firm, engaged in the engineering, construction and maintenance of railway-related facilities; an engineer employed by a technical service or research and development organization; or an officer or engineer of an engineering or scientific society or association whose aims and objectives are compatible with the aims and objectives of this Association. Any person desirous of becoming a member shall make application upon the form prescribed by the Executive Committee, setting forth the applicant's name, address and practical experience. The applicant shall be recommended by at least one member of the Association to whom they are personally known. Applicants may be voted into membership at any regular executive meeting or by letter ballot of the Executive Committee, a majority vote being necessary in either instance.

Section 3. To be eligible for a life membership, an individual must have belonged to the Association for at least 15 years and in general must have retired from active employment due to age or physical disability. A life member shall have all the privileges of previous membership, except the holding of office, and shall not be required to pay annual dues. The transfer from membership to life membership shall be made in the same manner as the election of members, as prescribed in Section 2 of this Article.

Section 4. Associate members shall be responsible persons who are not eligible as members, whose pursuits or attainments qualify them to cooperate with members in the study and development of improved practices in the construction and maintenance of railway structures and fixed facilities. They shall have all the rights of members except of voting and holding office. They shall be elected in the manner prescribed for members, in Section 2 of this Article, except that they shall be recommended by either a member or an associate member of the Association to whom they are personally known.

Section 5. Honorary members shall be chosen from persons who have attained acknowledged eminence in some branch of engineering or railway service. Their number shall be limited to ten. Honorary members shall be proposed by not less than six active members and shall be elected by the majority vote of the members present at a regular meeting. They shall have all the rights of members except that of holding office and shall be exempt from the payment of dues.

Section 6. Any person in the Association membership whose conduct in any way diminishes the professionalism or prestige of the Association, or who shall refuse to comply with the rules of this Association, shall forfeit membership in the Association on a two-thirds vote of the Executive Committee.

Section 7. Membership shall continue until written resignation is received by the secretary, unless member has been previously expelled, or dropped for non-payment of dues in accordance with Section 1 of Article VII.

Section 8. Only members shall hold office in this Association, and only members and qualified life members shall be entitled to vote in the election of officers.

Section 9. Junior members shall be persons engaged in academic study toward a career in those areas described in Section 2 of this Article, but not currently employed in those areas. They shall have all the rights of members except of voting and holding office. They shall be elected in the manner prescribed for members in Section 2 of this Article, except that they need not be recommended by a member of the Association. The term of junior membership shall be limited to five years.

ARTICLE IV

OFFICERS

Section 1. The officers of the Association shall be a president, a senior vice president, two junior vice presidents, a treasurer and nine directors, who, with the most recent past president, shall constitute the Executive Committee.

Section 2. The past presidents of this Association, previous to the most recent past president, who continue to be members shall be privileged to attend all meetings of the Executive Committee, of which meetings they shall receive due notice, and be permitted to discuss all questions and to aid said committee by their advice and counsel; but said past presidents shall not have a right to vote, unless called upon to fill a quorum.

Section 3. Vacancies in any office shall be filled for the unexpired term by the Executive Committee without delay.

ARTICLE V

EXECUTIVE COMMITTEE

Section 1. The Executive Committee shall manage the affairs of the Association and shall have full power to control and regulate all matters not otherwise provided for in the constitution and by-laws and shall exercise general supervision over the financial interests of the Association, and make all necessary purchases and contracts required to conduct the general business of the Association, but shall not have the power to render the Association liable for any debt beyond the amount then in the treasury plus accounts receivable and not subject to other prior liabilities. All appropriations for special purposes must be acted upon at a regular meeting of the Association.

Section 2. Meetings of the Executive Committee may be called by a majority of the members of the committee, providing ten days' notice is given to the executive committee by mail.

Section 3. Five members of the Executive Committee, one of which shall be either the president or a vice president, shall constitute a quorum for the transaction of business.

ARTICLE VI

ELECTION OF OFFICERS AND SECRETARY AND TENURE OF OFFICE

Section 1. Except as otherwise provided, the officers shall be elected at the regular annual meeting of the Association and the election shall not be postponed except by a two-thirds vote of the members present at said annual meeting. The election shall be by vote, a majority of the votes cast being required for election. Any member of the Association not in arrears for dues shall be eligible for office, but the president shall not be eligible for re-election.

Section 2. The president, two junior vice presidents, and treasurer shall hold office for one year and the directors for three years; three directors being elected each year. The senior vice president shall hold office for one year and ascend to the office of president at the expiration of such service. All officers shall retain their office until their successors are elected and installed. A director elected for a three-year term shall not be eligible to serve two consecutive terms.

Section 3. The term of office of the treasurer may be terminated at any time by two-thirds vote of Executive Committee. The compensation of the treasurer shall be fixed by a majority vote of the Executive Committee.

Section 4. The secretary shall be appointed by a majority vote of the Executive Committee and the term shall terminate with the appointment of successor. The Executive Committee shall have the power, by two-thirds vote, to remove the secretary and appoint a successor at any time. The salary of the secretary shall be decided by a majority vote of the Executive Committee.

Section 5. The secretary and the treasurer shall be required to give bond in an amount to be fixed by the Executive Committee.

ARTICLE VII

MEMBERSHIP FEE AND DUES

Section 1. Every member, upon joining this Association, shall pay to the secretary an entrance fee and dues as prescribed by the executive committee. No member in arrears for annual dues shall be entitled to vote at any election and any member more than one year in arrears may be stricken from the list of members at the discretion of the Executive Committee.

Section 2. A person stricken from the list of members because of non-payment of dues upon written application may be reinstated as a member in the former class of membership without loss of privileges, either upon payment of all back dues (which must accompany applications) or at the discretion of the Executive Committee voting in the manner prescribed in Section 2 of Article III.

ARTICLE VIII

LOCAL SECTIONS

Section 1. Upon the application of ten or more members of the Association residing in the same geographical district, or having offices therein, the Executive Committee shall organize a local section for that district, to which all members in that district shall be eligible. Such local section shall admit to active membership only members in good standing. It shall hold not less than two meetings each year, and shall be governed by such constitution and by-laws not inconsistent with the constitution of this Association as the section membership may adopt and the Executive Committee approve.

Section 2. The parent Association shall not be put under any obligation, either financial or in the matter of policy or opinion, by any local section.

ARTICLE IX

AMENDMENTS

Section 1. This constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that notice of the proposed amendment or amendments has been sent to the members at least 30 days previous to said regular meeting.

By-Laws

(Revised July 11, 1994)

Time of Meeting

1. The regular meeting of this Association shall convene annually during the month of September, the exact date to be fixed by the Executive Committee.

2. It shall be within the power of the Executive Committee to change the time of the meeting if it becomes apparent that it is for the best interests of the Association.

Place of Meeting

3. The place of holding the annual meeting shall be determined by the Executive Committee not less than twelve months prior to the date of the annual meeting.

Quorum

4. At the regular meeting of the Association, 15 or more members shall constitute a quorum.

Dues

5. The annual dues for the fiscal year ending August 31, and payable in advance, shall be as follows:

Members, $25.00; Associate Members, $25.00; Junior Members, $25.00

Duties of Officers

6. The president shall have general supervision over the affairs of the Association. He shall preside at all meetings of the Association and of the Executive Committee; shall appoint all committees not otherwise provided for, and shall be ex-officio member of all committees. The president (or appointed Executive Committee member) shall render a detailed report at least three times during the year to the members of the Executive Committee, showing the financial condition of the Association and its activities.

At the annual meeting the president (or appointed Executive Committee member) shall present a report containing a statement of the general condition of the Association.

7. The vice presidents, in order of seniority, shall preside at meetings in the absence of the president and discharge the duties of the president in case of a vacancy in his office. The senior vice president shall have the senior position of vice presidents.

8. The secretary shall keep a correct record of the proceedings of all meetings of this Association, and of all accounts, between this Association and its members, collect all moneys due the Association, and deposit the same in the name of the Association. The secretary shall pay all bills when properly certified and approved by the president or the treasurer, and make such reports as may be called for by the Executive Committee. The secretary shall sign all contracts or other written obligations of the Association which have been approved by the Executive Committee. The secretary shall also perform such other duties as the Association may require.

9. The treasurer shall have charge of the funds, check all deposits as made by the secretary, and invest all funds not needed for current expenses. The treasurer shall report at each annual meeting on the condition of the finances.

Nominating Committee

10. After each annual meeting the president shall appoint a committee consisting of five members. The most immediate past president shall act as chairperson. No other officers of the Association shall be appointed to this committee. This committee shall prepare a list of names of nominees for officers to be voted on at the next annual meeting in accordance with Article VI of the Constitution, said list to be read at the business session of said meeting. Nothing in this section shall be construed to prevent any member making further nominations provided that such nominations are received by the president in writing not less than thirty (30) days in advance of the first day of the annual meeting. Such nominations should be addressed to the president of the Association at its headquarters office.

Auditing Committee

11. Prior to each annual meeting the president shall appoint a committee of three members, not officers of the Association, whose duty it shall be to examine the accounts and vouchers of the secretary and the treasurer and certify as to the correctness of their accounts.

Orders of Business

12. The order of business at the annual meeting of the Association shall be as follows:

- Call to order by president
- Opening prayer or invocation
- President's address
- Presentation of papers, reports and special presentations
- Reports of standing committees
- Business Session
  - Report of Secretary
  - Report of Treasurer
  - Report of Auditing Committee
  - Report of Nominating Committee
  - Election of Officers
  - Necrology Report
  - Unfinished business
  - New business
- Installation of officers
- Adjournment

The order of business may be modified by the Executive Committee prior to the meeting, and is subject to change by the chair, unless protested by a majority vote of members present.

Decisions

13. The votes of a majority of the members present shall decide any questions, motion or resolution which shall be brought before the Association, unless otherwise provided. Unless specifically provided herein otherwise, all discussions shall be governed by Robert's Rules of Order.

Amendments

14. The By-Laws can be amended by a two-thirds vote of those present at any regularly called Executive Committee Meeting.

MEMBERSHIP DIRECTORY

ACTIVE MEMBERS

Joined

Adams D A, Mgr Bridge Mtce, UP RR, RR 1-Box 326, Virgil, KS, 66870-9728 09-26-84
Adams J A, B&B Supv, CSX Transportation, 522 Upland Ct, Murfreesboro, TN, 37129-6644 11-18-94
Anderson B R, Engr Of Trk, Conrail, 850 N Henderson Rd, King Of Prussia, PA, 19406 10-04-82
Anderson T P, Bridge Foreman, UP RR, 310 6th Ave N, S St Paul, MN, 55075 04-06-93
Applegate D, Mgr Of Bridge Mtce, UP RR, 833 E 8th St, Stockton, CA, 95206 07-24-91
Arnold R C, Assoc Prof, U Of Nebraska At Omaha, Eng 125A, Omaha, NE, 68182 12-06-93

Bagwell M W, VP/GM, Mississippi Export RR, PO Box 8743, Moss Point, MS, 39562-8743 03-16-88
Baker R C, Engr Trk & Strs, EJ&E RY, 1141 Maple Rd, Joliet, IL, 60434 09-14-80
Barrett J E, President, Bowman, Barrett & Assocs, Inc., 130 E Randolph St #2650, Chicago, IL, 60601-6207 12-09-71
Barrett P L, Engr. Field Proc., BNSF, 4515 Kansas Ave, Kansas City, KS, 66106 02-17-82
Bartholomew D E, Sr Proj Mgr RR Facilities, Sverdrup Civil, Inc., 600--108th Ave NE-Ste 700, Bellevue, WA, 98004-5110 09-15-86
Bateman J D, Mgr Bridge Mtce, UP RR, RR 2, Box 56, Jacksonville, TX, 75766 12-03-82
Beard E E, B&B Supv, IC RR, RR 1, Box 69B, Sigel, IL, 62462 07-24-91
Beck C, Supv B&B, NICTD, 601 N Roeske Ave, Michigan City, IN, 46360 01-06-93
Beebe L C, Mgr Sfty Srvcs, UP RR, 1416 Dodge St, Rm 800, Omaha, NE, 68179 12-04-85
Begg W B, Engr Of Strs, CC&P RR, 402 E Fourth St, Waterloo, IA, 50704 10-08-91
Begnaud R A, Engineer II, Amtrak, 2961 Hale St, Philadelphia, PA, 19149 05-08-84
Beirne J M, Mgr Trk Insp & Dvlpmnt, NS Corp, 110 Franklin Rd SE, Roanoke, VA, 24042-0077 08-20-76
Beitzel M J, Sr Engr Tech, Modjeski & Masters, 7129 Meadowbrook Dr, Mandeville, LA, 70471 09-22-91
Belkaloul E, Sr Bridge Engr, Transport Canada, 344 Slater St, Ottawa, ONT, CAN, K1A 0N5 09-16-90
Bennett C P, Asst Engr-Grd Sprtn Strs, NS Corp, 99 Spring St SW, Atlanta, GA, 30303 01-09-90
Bennett D W, Asst B&B Supv, Montana Rail Link, Box 8779-IOI Int'L Way, Missoula, MT, 59807 04-23-92
Bennett R M, Professor, U Of Tennessee, Department Of Civil Engr, Knoxville, TN, 37996-2010 07-11-94
Benton W, Engr. Structures, NS Corp, 99 Spring St SW, Atlanta, GA, 30303 08-17-88
Beran J R, Chf Engr, UP RR, 1416 Dodge St Rm 1000, Omaha, NE, 68179 09-07-83
Bhalakia M P, Consultant, Engineering Srvcs, 8251 E Van Buren Dr, Pittsburgh, PA, 15237-4405 09-16-73
Bibly K C, Mgr Pwr Hse, Amtrak, 210 S Canal St, Chicago, IL, 60606 10-10-67
Biddy L D, Supv Bridges, CSX Transportation, 4100 Vanderbilt Rd, Birmingham, AL, 35217 03-22-95
Billings J D, Mgr Bridge Mtce, UP RR, 375 Beech St, Chadron, NE, 69337 10-03-74
Billingsley R E, Gen B&B Supv, NS Corp, 8 N Jefferson St, Roanoke, VA, 24042-0049 12-05-86
Bilson T E, Asst Div Engr-Strs, Conrail, 53 Manchester Rd, Sewell, NJ, 08080 07-11-94
Birgenheier J A, Engr Strl Mtrls, BNSF, 4515 Kansas Ave, Kansas City, KS, 66106-1199 02-06-89
Bishop G L, Strl Dtlr, NS Corp, 99 Spring St, Atlanta, GA, 30303 09-20-87
Blackley M G, Bridge Inspector, UP RR, 3095 Main St, Missouri Valley, IA, 51555 03-27-96
Boileau R J, AVP-Constr, BNSF, 4515 Kansas Ave, Kansas City, KS, 66106 03-27-85
Bonas D J, Asst Engr Strs, NS Corp, 99 Spring St SW, Atlanta, GA, 30303 11-02-83
Bond E, Chf Engr Br & Strs (Ret.), NS Corp, 2695 S Arbor Dr, Marietta, GA, 30066 09-28-66
Boraas R S, Br Engr -Des & Const, UP RR, 1860 Lincoln St., 5th Fl., Denver, CO, 80295 10-02-86
Borden L V, Sr Associate, Modjeski & Masters, 4909 Louise Dr, Mechanicsburg, PA, 17055 02-05-91
Borg M T, Mgr B&B-Network Mgmnt, BNSF, 42052 Pearson Ranch Loop, Parker, CO, 80134-4457 02-24-84
Bothwell F J, Structures Supvr., Canadian National RY, 197 York St., London, ONT, CAN, N6A 1B3 09-16-90
Bowman R L, Sr Metallurgical Engr, NS Corp, 110 Franklin Rd SE-Box 77, Roanoke, VA, 24042-0077 05-19-95
Bradley J G, Asst Div Engr-Bridges, NS Corp, PO Box 14820, Knoxville, TN, 37914 06-07-90
Bradley M L, Proj Engr, Conrail, 1335 Dublin Rd-Ste 112A, Columbus, OH, 43215 08-31-82
Brantley B, Dsgn Engr, Alfred Benesch & Co, 205 N Michigan Ave-Blvd Twrs S, Chicago, IL, 60601 09-18-94
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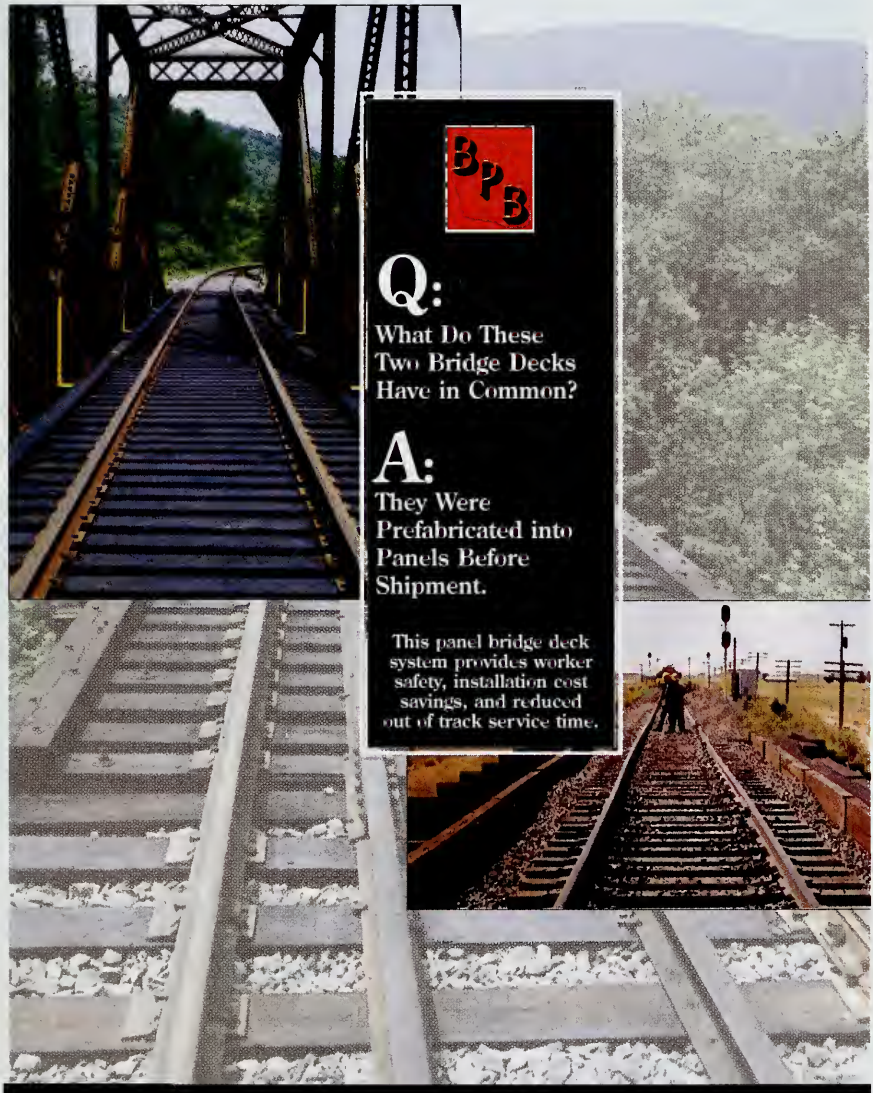
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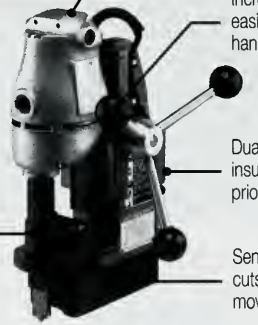

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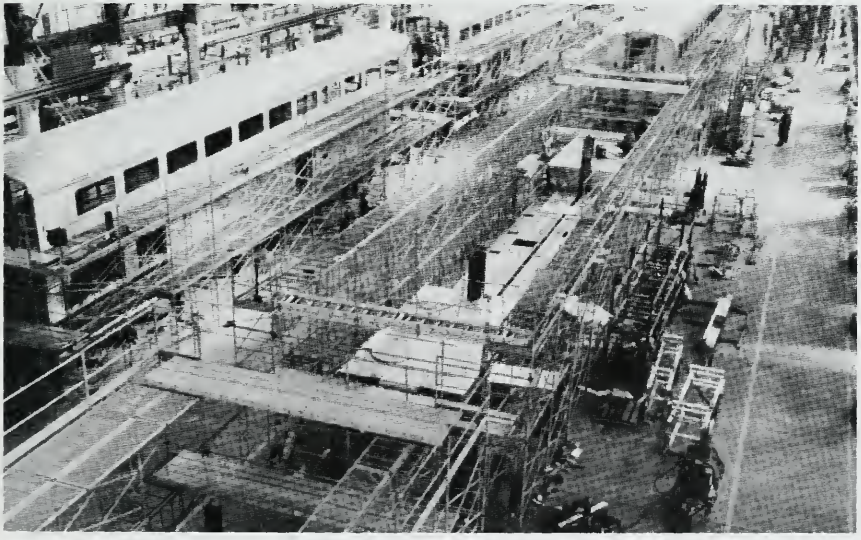

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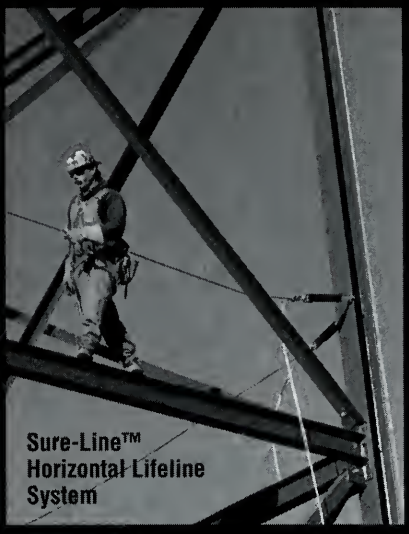

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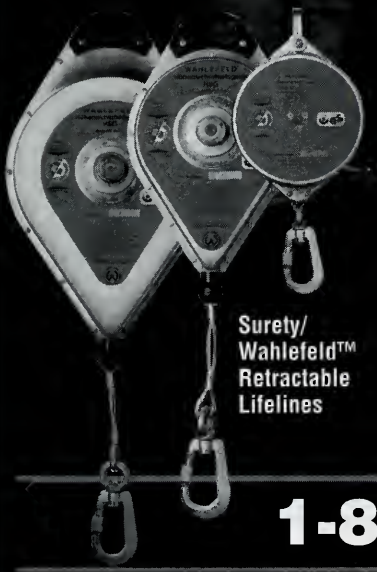

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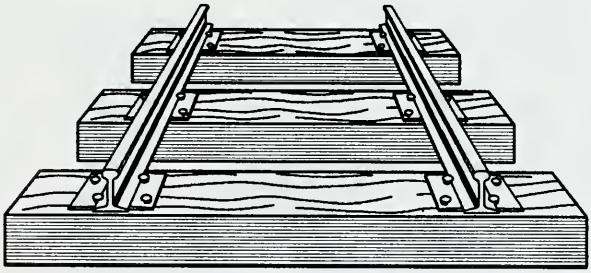

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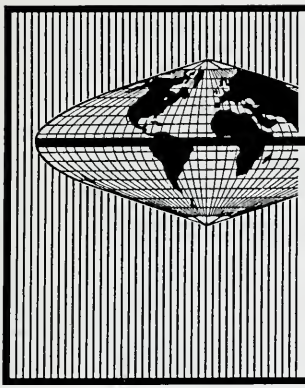

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